GEM TN-92-141

Collaboration Council Meeting - SSCL

August 5, 1992

Abstract:

Agenda and presentations of the GEM Collaboration Council Meeting held at the SSC Laboratory on August 5, 1992. Agenda items were: GEM Status and News; Discussion of PAC Review; Report from GEM Project Office; Status and Plans of GEM Systems: Magnet, Trigger, Central Tracker, Calorimetry, and Muons; and TDR Planning.

GEM Collaboration Council
AGENDA

August 5, 1992
9 a.m. – 3 p.m.

I) GEM Status and News (Barish)

II) Discussion of PAC Review - 20 minutes

III) Report from GEM Project Office (Sanders) - 15 minutes

IV) Status and Plans for GEM systems

- Magnet (Stroynowski) - 15 minutes
- Trigger - (Marlow) - 15 minutes
- Central Tracker (Baltay) - 15 minutes
- Calorimetry
  - S. Majewski - results and conclusions of BaF_2 panel - 15 minutes
  - Yu. Kamyshkov - How we will proceed with the decision on the choice of E–M calorimeter - 10 minutes
  - H. Gordon - LKr/Ar Eng. Design Report presentation and first results from beam tests - 20 minutes
  - H. Newman - Progress report on BaF2 and radiation damage studies - 20 minutes
  - B. Worstell - First results of beam tests of Scint. Fiber Hadron Calorimeter - 10 minutes
- Muons
  - F. Taylor - Status - 20 minutes
  - I. Golutvin - Progress of Dubna - 15 minutes

V) TDR Planning - 10 minutes

We are planning a GEM dinner on WEDNESDAY night at SSCL. This is the night before the Dallas Conference and we expect a good turnout for the dinner. Please plan on it!!!

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Presentation by:

Barry Barish

BARISH

GEM
Collaboration Council

Aug 5, 1992

Status + News

- SSC Status
  - Senate Vote
  - Senate / House Conference
  - $
- PAC Report / Implications
  - Magnet
  - TDR
  - Calorimetry
- Organization
- **GEM DINNER @ SSC** TONITE 2PM

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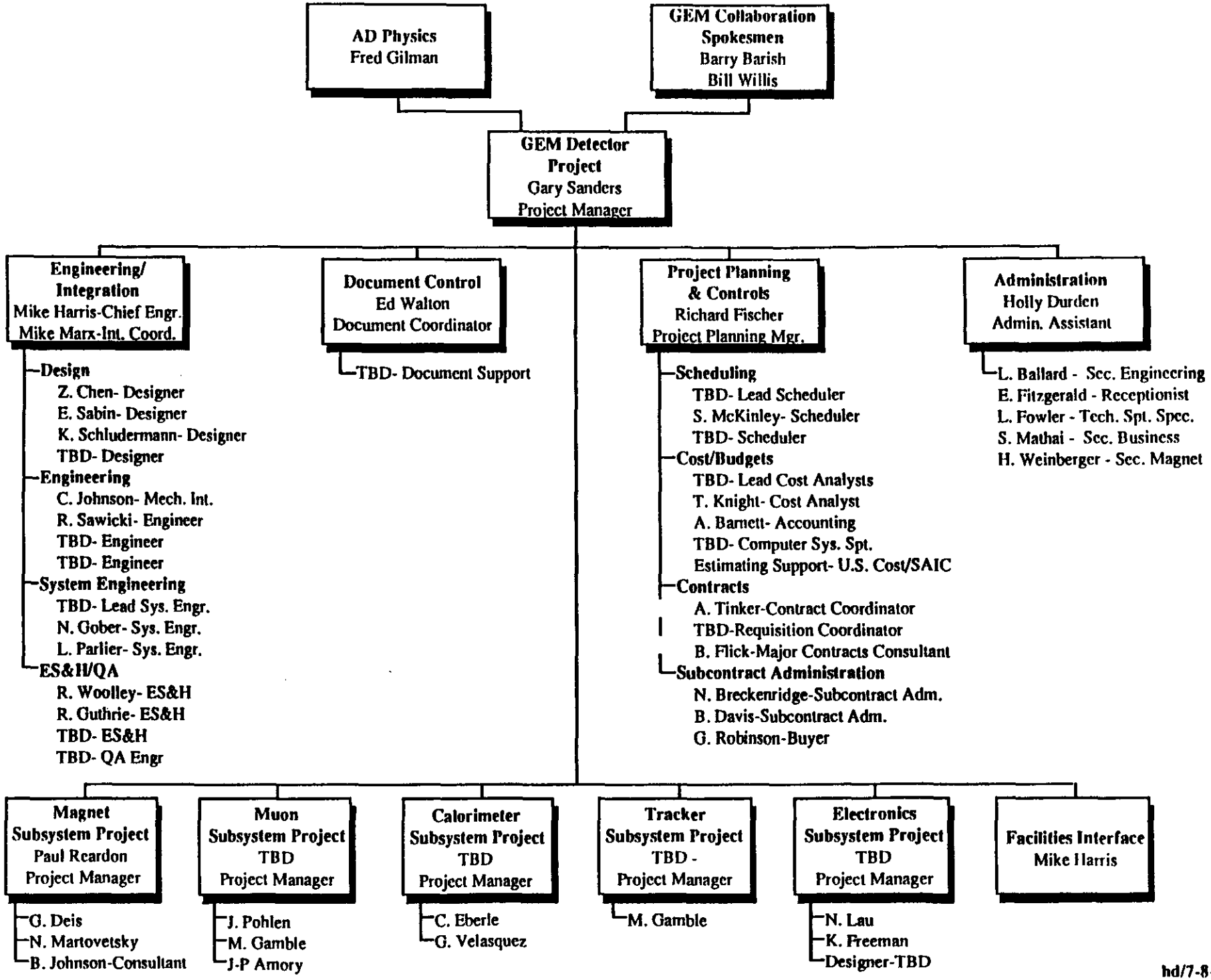
Presentation by:

Gary Sanders

GEM Project Department



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REPORT ON THE GEM PROJECT

THE FIRST 6 MONTHS

1. Build a project team (management, engineering, integration, planning, business functions, QA, ES&H, document control, configuration management)

2. Develop a baseline cost estimate

3. Organize magnet subproject

4. Budget and expenditure control and tracking

5. Administrative support

IN PROGRESS:

6. Integrated project schedule

7. Design requirements, specification tiering

8. Subsystem management and subsystem engineering

9. R&D and engineering budget planning for FY93

10. International coordination and organization

RECENT MILESTONES

1. Cost estimate reviewed successfully

2. Magnet technical design reviewed successfully

3. Magnet env. analysis review in progress in Washington

4. DOE has approved magnet acquisition plan

5. Draft magnet RFP circulated to industry and comments received

6. First significant foreign contribution arrives (Dubna PDT array) for TTR (GEM Project Dept. and physics collaboration)

7. TTR ES&H and readiness review

8. Russian, Chinese, Albanian, Ecuadorian, Korean and Taiwan collaboration building in full swing.

FY93 BUDGET PLANNING

1. Assume level or slightly better $ in FY93 than in FY92

2. GEM - FY92 - $17 million ($5 million magnet, $2 million PM)

3. STAY ON SCHEDULE SCENARIO - FY93 $33-36 million ($15 million magnet)

4. ONE YEAR DELAY SCENARIO - Critical path + "keep-alive" = $22 million ($8.6 magnet)

5. Level = $17 million - some efforts die

BUDGET PLANNING INFO. FROM SUBSYSTEMS ASSEMBLED BY BOB WEBB, MIKE HARRIS REVIEWING ENGINEERING. THIS MONTH WEBB, HARRIS, FISCHER, SANDERS WILL DRAFT PLAN FOR COLLABORATION COMMENT.

FY93 will only work if technologies narrowed and base-HEP program support utilized.

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Presentation by:

Majewski

Majewski

Agenda for the Third BaF_2 Panel Meeting
Dallas, 03-04 August 1992

SSCLab, Building 4, Strategy Room
Monday, August 3, 1992

(The asterisk (*) used when GEM BaF_2 and/or GEM representatives will be present).

9:00 *Opening Remarks*, Fred Gilman, Harvey Lynch (SSCL)

9:15 *Reminder of the Charge, Discussion of the Agenda*, Harvey Lynch (SSCL)

9:30* *Reports on the Latest R&D Activities and Status by the GEM BaF_2 Group*:
(1) *Activities in the US*
(2) *Work in China,* by Harvey Newman, Ren-Yuan Zhu

10:30* *Short Summary of the Stability Requirements*, Yuri Kamyshkov (GEM)

10:40* Coffee Break

11:00* *Material Characterization of BaF_2 at CEA*, Michael Strathman

11:55* *Spectroscopic Characterization of Point Defects in BaF_2*, Larry Halliburton (University West Virginia)

12:15* Working Lunch (Strategy Room)

13:00* *Gamma, Neutron and Hadron Radiation Damage Studies of BaF_2*, Craig Woody

13:30* *Surface Preparation and Analysis, Reflective Coating, High Purity Crystal Growing*, Craig Wuest, Ben Fuchs (Livermore)

14:15* *Site Visit of Several Facilities in China*, Craig Wuest (Livermore)

15:00* *Short Contributions*, by different speakers

15:30* Coffee Break

16:00 *Comments on Important Issues*, Paul Schotanus

16:30 *Round Table Technical Discussion* (and the proposed discussion leader):
- Summary of BaF_2 Radiation Damage Situation (Craig Woody)
- Feasibility of Pre-Irradiation Treatment, Saturation, Recovery (Self-annealing) and Theoretical Understanding of the Effects (Paul Schotanus)
- Summary of Material Analysis Results (Michael Strathman))
- Production of High Purity Crystals with Good Surface Quality (Robert Sparrow)
- Evaluation of the Production Efforts in China (Robert Sparrow)

18:00 Meeting Adjourned

19:30 Dinner at Javier's

SSCLab, Building 4, Strategy Room

Tuesday, August 4, 1992

8:15* *Meeting with the GEM Collaboration Representatives*

9:00 *Continuation of the Panel Technical Discussion*

10:15 Coffee Break

10:45 *Panel Recommendation, Preparation of the Report:*
Assessment of Radiation Hardness of Crystals
Assessment of Production Capability
Still Unsolved Issues Relevant to the Technology Choice
"Final" Recommendation

12:00 Working Lunch

13:00 *Continuation of Preparation of the Panel Report*

15:00 *Discussion of the Draft by the Panel*
Preparation of the Revised Version

17:15 End of Meeting

BaF2 Committee and Associates

Comm. Member	Name	Institution	Address	Cty	Phone	Fax	Bitnet
√	Abraham, Marvin	Oak Ridge National Lab	PO Box 2008 Bldg 2000 MS6056 Oak Ridge, TN 37831	USA	615-574-6282 615-5745491	615-574-4143	
	Barish, Barry	CalTech	Dept Physics 256-48 Lauritsen Lab Pasadena, CA 91125	USA	818-356-6684	818-795-3951	
√	Chen, Yok	Oak Ridge Natl Lab USDOE	PO Box 2008 Bldg 3025 MS6024 Oak Ridge, TN 37831 Div. Matl. SciencesER 131 Washington, DC 20585	USA	615-574-6284 301-903-3428	615-574-4143 301-903-6594	
√	Craig, Richard A.	Batelle Memorial Inst Pacific NW Lab	K5-25 PO Box 999 Richland, WA 99352	USA	509-375-6907	509-375-3614	D37813@PNLG.PNL.GOV (Internet)
√	Dozier, Charles	Naval Research Lab	Code 4682 4555 Overlook SW Washington DC 20375	USA	202-767-2154 202-767-2993	202-767-4868	
√	Drukier, Andrew		7986 Lakecrest Drive Greenbelt MD 20770	USA	301-864-0816 301-982-9808	301-864-0816	drukier@umdhep.BITNET
√	Fuchs, Ben	Lawrence Livermore National Laboratory	P.O. Box 808 - L-331 Livermore, CA 94550	USA	510-294-2619	510-422-1290	
√	Halliburton, Larry	West Virginia University	Physics Dept. Hodges Hall Morgantown, WV 26506	USA	304-293-3422 Ext. 442	304-293-5732	
	Kamyshkov, Yuri	Oak Ridge National Lab	Physics Bldg 6003 Bethel Valley Road Oak Ridge, TN 37831-6372	USA	615-576-6914	615-576-2822	kamyshkov@orph01 -or- vxcern::kamyshkov
√	King, Steve	Naval Research Lab	Code 4616 4555 Overlook SW Washington DC 20375	USA	202-767-5692	202-767-6980	KING1@CCF.NRL.NAVY.MIL (Internet)
√	LeCoq, Paul	CERN	PPEDivision 1211 Geneve 23	Switz	41-22-782- 7523	41-22-782- 7523	LECOQ@CERNVM
√	Lynch, Harvey	SSCL	SSCL 2550 Beckleymeade Dallas, TX 75237	USA	214-708-6037	214-708-0006	hll@SSCVX1
√	Majewski, Stanley	Continuous Electron Beam Accelerator Facility	12000 Jefferson Ave Newport News, VA 23606	USA	804-249-7448 804-249-7235	804-249-7363	Majewski@cebaf
	Newman, Harvey	CalTech	Dept Physics 256-48 Lauritsen Lab Pasadena, CA 91125 Aug. 12-28 ONLY: CERN PPE Division 1211 Geneva; Switzerland	USA	818-356-6656 Aug. 12-28 ONLY: 41227676366	818-795-3951 Aug. 12-28 ONLY: 41227828923	NEWMAN@CITHEX

√	Rothschild, Mordechai	MIT Lincoln Laboratory	244 Wood St Lexington MA 02173-9108	USA	617-981-7816	617-981-4983	
√	Schotanus, Paul		G Gezellelaan 72 2624 KZ DELFT	Neth	31-3406-69229 31-155-62860	31-3406-61471	schotanus@hutruu51
√	Sparrow, Rob	Optovac	North Brookfield, MA 01535	USA	508-867-6444	508-867-8349	
√	Strathman, Michael	Chas Evans and Assoc	301 Chesapeake Dr Redwood City, CA 94063	USA	415-369-4567	415-369-7921	
	Willis, Bill	Columbia	Nevis Lab PO Box 137 Irving-on-Hudson NY 10533	USA	914-591-8100 x208	914-591-8120	
√	Woody, Craig	Brookhaven Natl Lab	Physics Dept 510A 20 Pennsylvania St Upton, NY 11973	USA	516-282-2752	516-282-5568	woody@bnldag
√	Wuest, Craig	Lawrence Livermore National Laboratory	P.O. Box 808 - L-288 Livermore, CA 94550	USA	510-423-2909	510-423-8086	WUEST@LLNL.GOV
	Zhu, Ren-Yuan	CalTech	Dept Physics 256-48 Lauritsen Lab Pasadena, CA 91125	USA		818-795-3951	

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Presentation by:

Yuri Kamyshkov

Yu. Kamyshkov

DECISION PLAN

for E-M Technology Choice

July 1	at SSCL	GEM executive committee (presentation of decision plan for e-m technology choice)
July 1		Engineering Questions for LKr
July 27		Written LKr Engineering Status Report → August 3
August 3		Written Progress report from BaF2
August 3-4	at SSCL	BaF2 Experts Panel meeting
August 4	at SSCL	Meeting of LKr Engineering Panel → August 14
August 5	at SSCL	GEM Council meeting (Status reports)
August 5	at SSCL	GEM Exec Committee meeting (Review of status of R&D work for BaF2 and LKr)
August 9 (Sunday)	at SSCL	Cal.group meeting (e-m choice - first discussion)
during	August	LKr beam test analysis; Rad. damage tests of Large Chinese Crystals
Sept. 1		Final written progress reports
Sept. 2	at SSCL	Cal.group meeting (e-m choice - final discussion) (Spokesmen are invited)
Sept. 3	at SSCL	GEM Council meeting
Sept. 4	at SSCL	GEM Exec.Meeting (final discussion) Final decision on e-m technology for TDR

GEM Executive Committee requirements to BaF2 and LAr-Kr technologies

The Executive Committee at the meeting Feb. 20th has reviewed the status of e-m calorimetry R&D Programs and has formulated the list of requirements for each technology which should be met before the management of the Collaboration will proceed with the choice of one of the options. Our plan is to make the choice before the end of August 92, and preferably earlier. Response to the requirements must be reported to Collaboration management by the specified date or earlier, in order to allow proper consideration. It was noted by the Executive Committee that the BaF2 technology has a lower probability of success in its R&D Program, because of possible radiation damage and other effects which can destroy the small constant term in energy resolution.

A. Requirements for BaF2 technology :

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

   by August 1, 1992

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

   by August 1, 1992

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

   by July 1, 1992

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

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

   by July 1,1992

B. Requirements for LAr-Kr technology :

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

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

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

Additional requirements for LAr-Kr technology :

(proposed by individual members of exec. committee and members of calorimeter group)

by the time of e-m decision

1. Show Higgs -> 2 gamma spectra (mass range 80-150 GeV) for realistic e-m LAr-Kr detector and background simulations.

2. Provide detailed practical plan for calibration of LAr-Kr detector in situ. Provide an evidence that electronic calibration is equivalent to the detector calibration with the required accuracy.

3. Provide experimental proof of radiation stability of LAr-Kr e-m system (for actually used materials).

4. Provide the results of the benchmark tests of LAr-Kr electronics which demonstarate required linearity, dynamic range, white and coherent noise in the real accordion system, cross talks and means of linearity calibration.

DECISION:

In August, a decision will be made between the two technologies based on our best judgement of the expected performance of each technology, balanced against the cost and risk involved in each. A primary choice will be made for our e-m calorimeter for the TDR. Depending on the status of open questions at the time of making the decision, a strategy will be developed for continuing the development of the second technology at a considerably lower level, while these outstanding issues are resolved for the primary option and to allow the proponents to smoothly finish their R&D program.

The final decision will be made by the spokesmen, after considering the evidence presented for each technology and receiving the advice of the Executive Committee.

LAr/Kr Engineering Panel

- Engineering Design Report - available today
- Meeting of Panel is set for August 14
- Panel members:

  F. Taylor
  J. Brau
  N. Martovetsky
  R. Barber
  - A. Nikitin
  - Chinese Engineer

  B. Mousllini (Eagle)

  Ex. of.

  M. Harris
  M. Marx
  Y. Kamyshkov
  M. Rennich

- Chairman will be named in 1-2 days
- More engineers!

$H^0 \to 2\gamma$ Physics Task Force

G. Mitselmakher (coordinator)
F. Paige
T. Skwarnitski
A. Golutvin
S. Vanyashin
K. McFarlane
H. Ma
H. Yamamoto
R. Zhu (consultant)
K. Shmakov
D. Marlow
I. Sheer
T. Sjostrand (CERN)

"Panel"* Meeting In Late August

- Progress on Large Crystal Production in China
- Small Crystal Production: LLNL, OPTOVAC
- Data Relating Materials Properties to Radiation Damage: CEBA, WVU
- CR TOWER + UV MONITOR Stability Data
- Simulations on Uniformity, Calibration, Stability & Resolution
- Attendance By Chinese Leaders of the Effort on BaF2:

  Jin, Li, Wang

* OR SubPanel.

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Presentation by:

Howard Gordon

Aug. 5, 1992

Liquid Argon / Krypton Calorimetry

Progress Report

1) Engineering review – Aug. 14, 1992

NO CHAIR

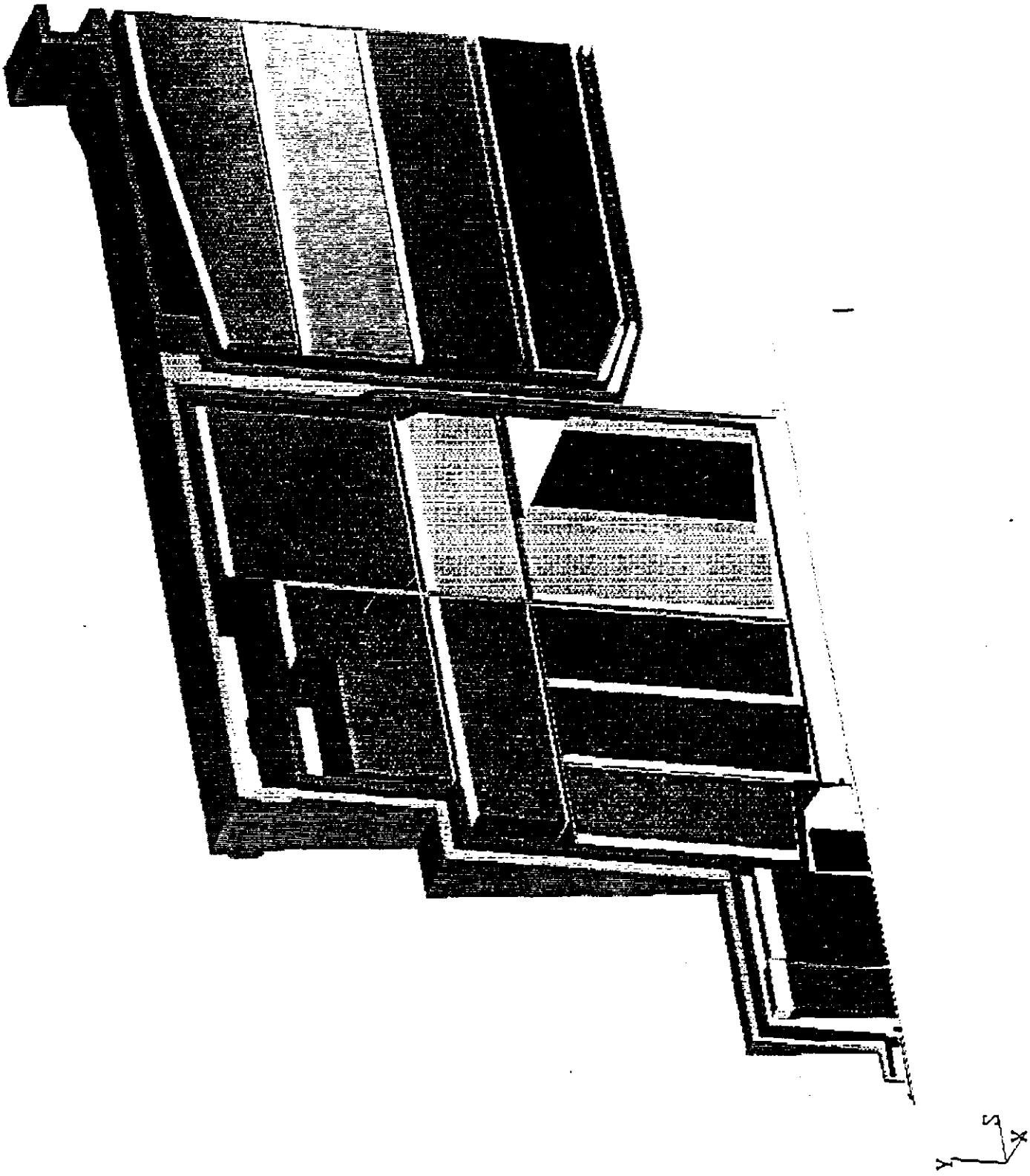
good questions – (answers?)

further discussion Aug. 9

2) Preliminary results from BNL Beam Tests

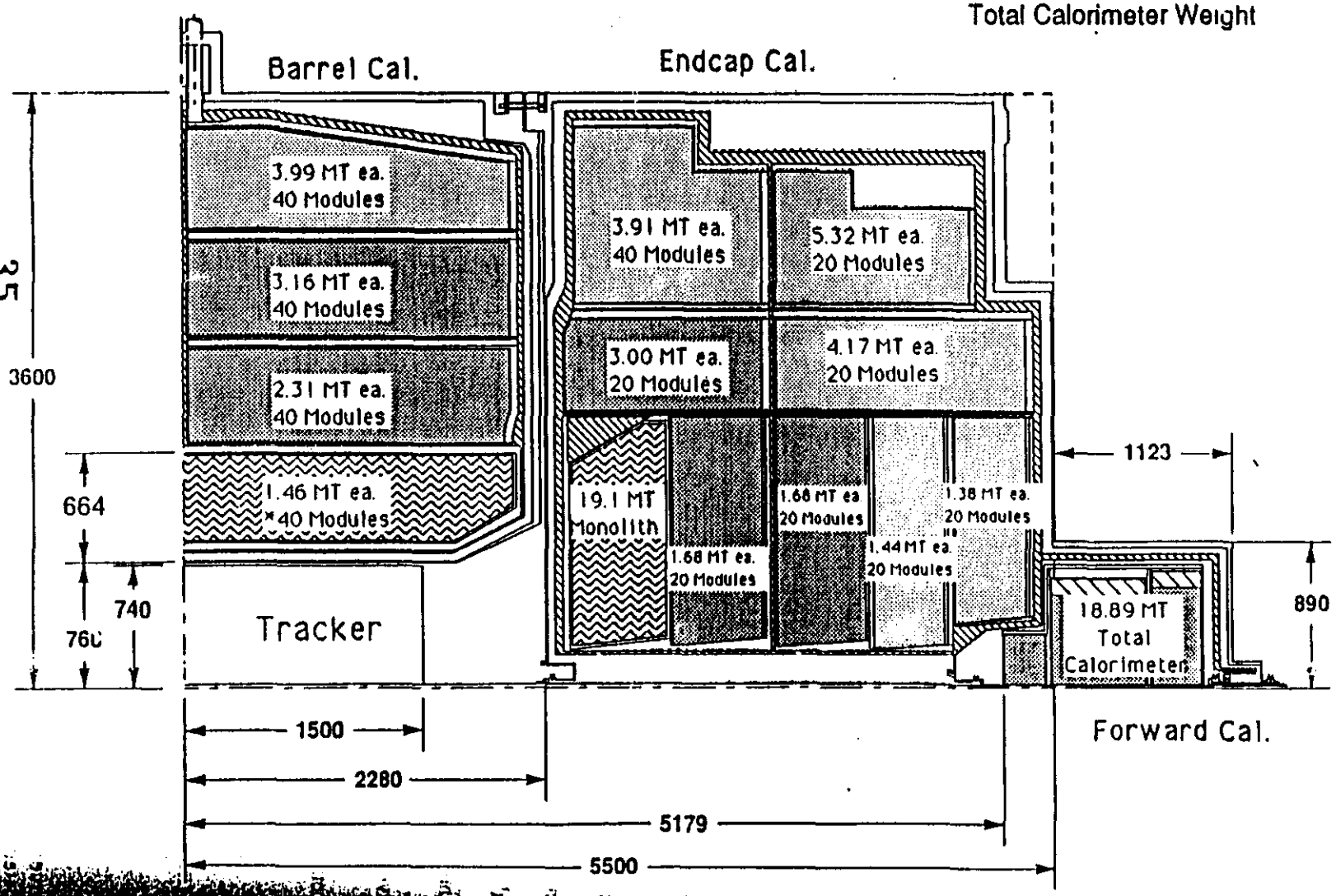
Details will be given on Sunday, Aug. 9

Further results in Sept.

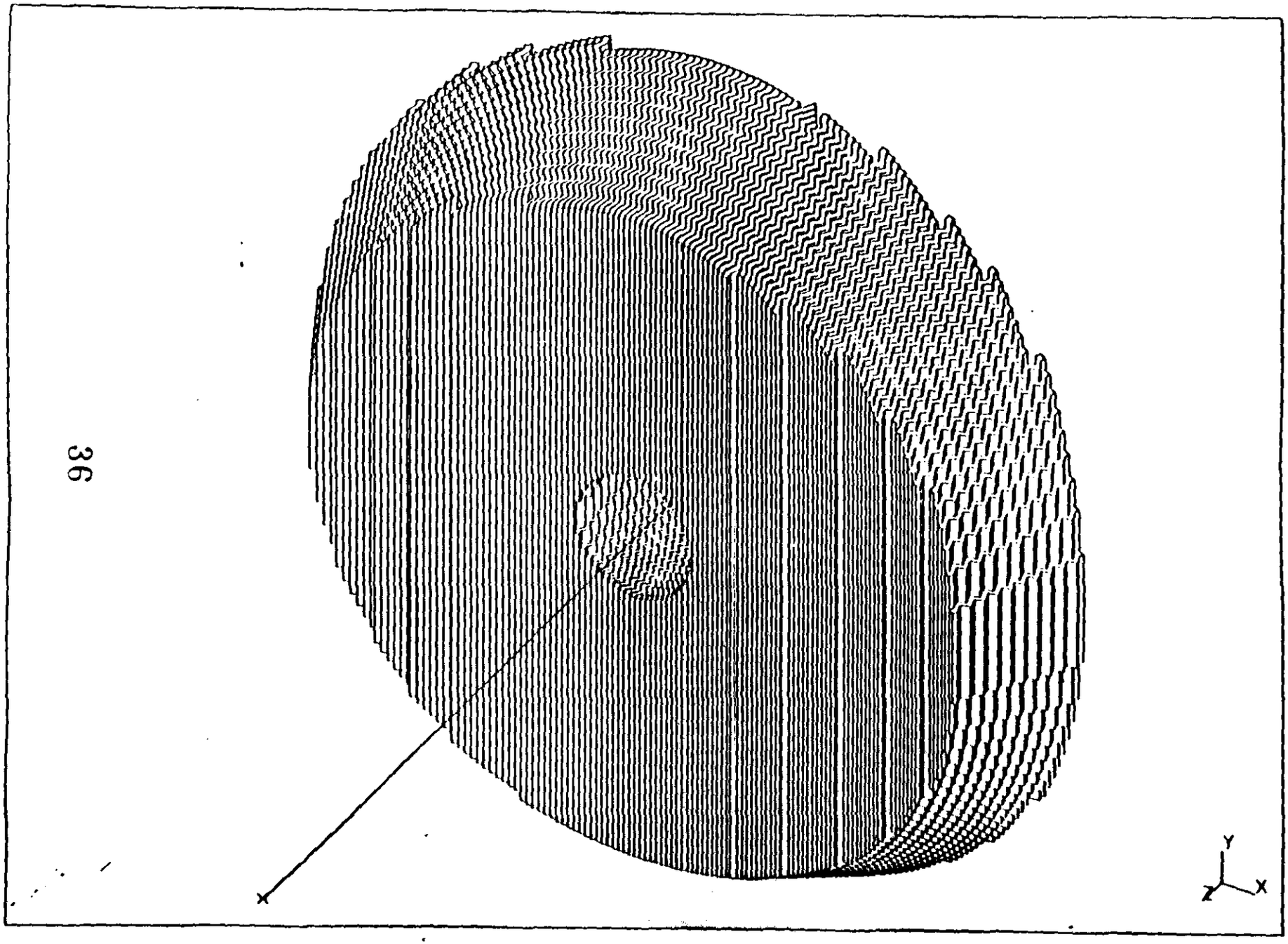


LIQUID ARGON CALORIMETER - 12 X 14 LAMBDA, FLAT ENDCAP HEAD

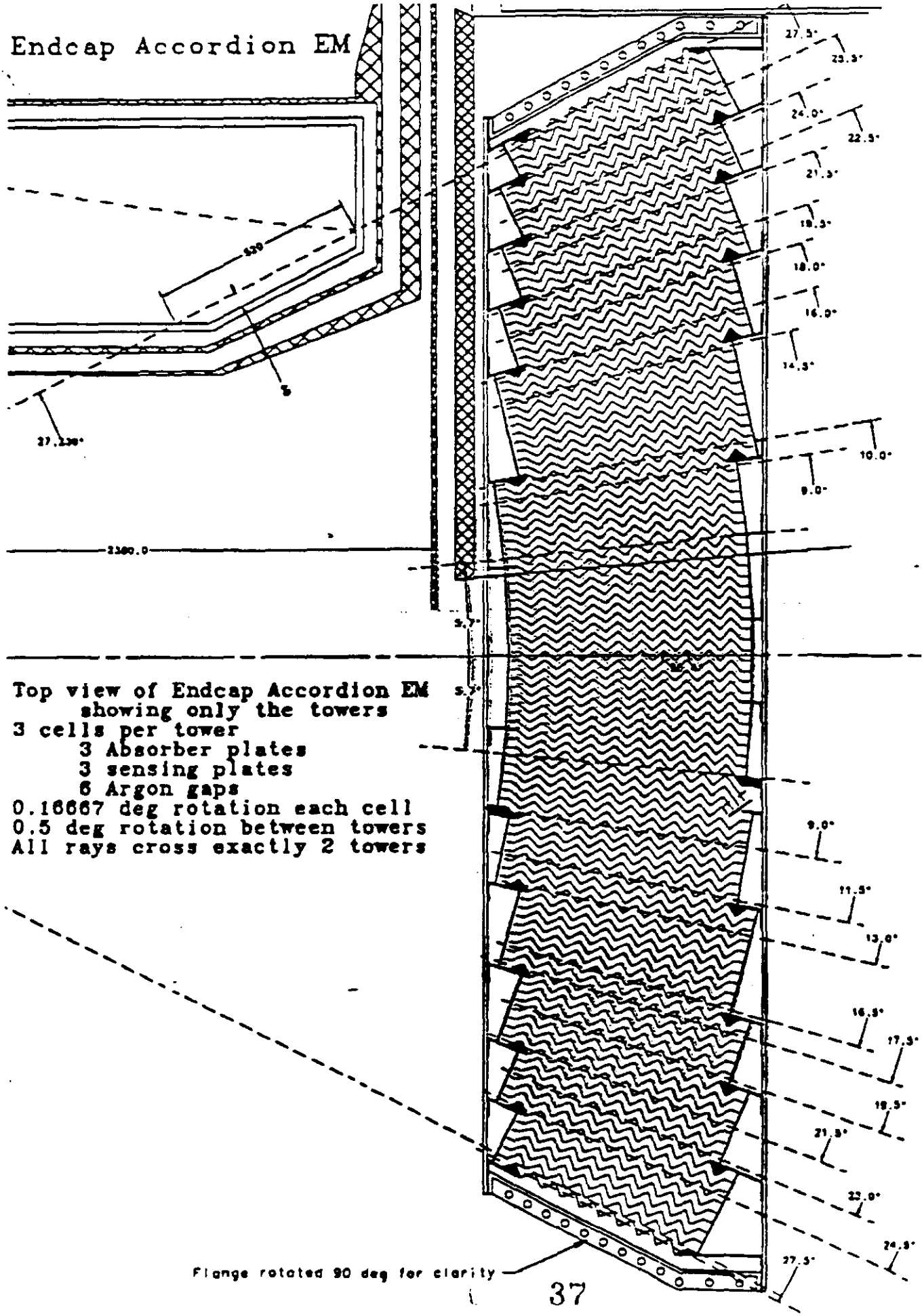
Central Barrel Calorimeter Weight	891 MT
Endcap Calorimeter Weight Each	626 MT
Total Calorimeter Weight	2,143 MT



Endcap Accordion EM



Endcap Accordion EM



Top view of Endcap Accordion EM
showing only the towers
3 cells per tower
3 Absorber plates
3 sensing plates
6 Argon gaps
0.16667 deg rotation each cell
0.5 deg rotation between towers
All rays cross exactly 2 towers

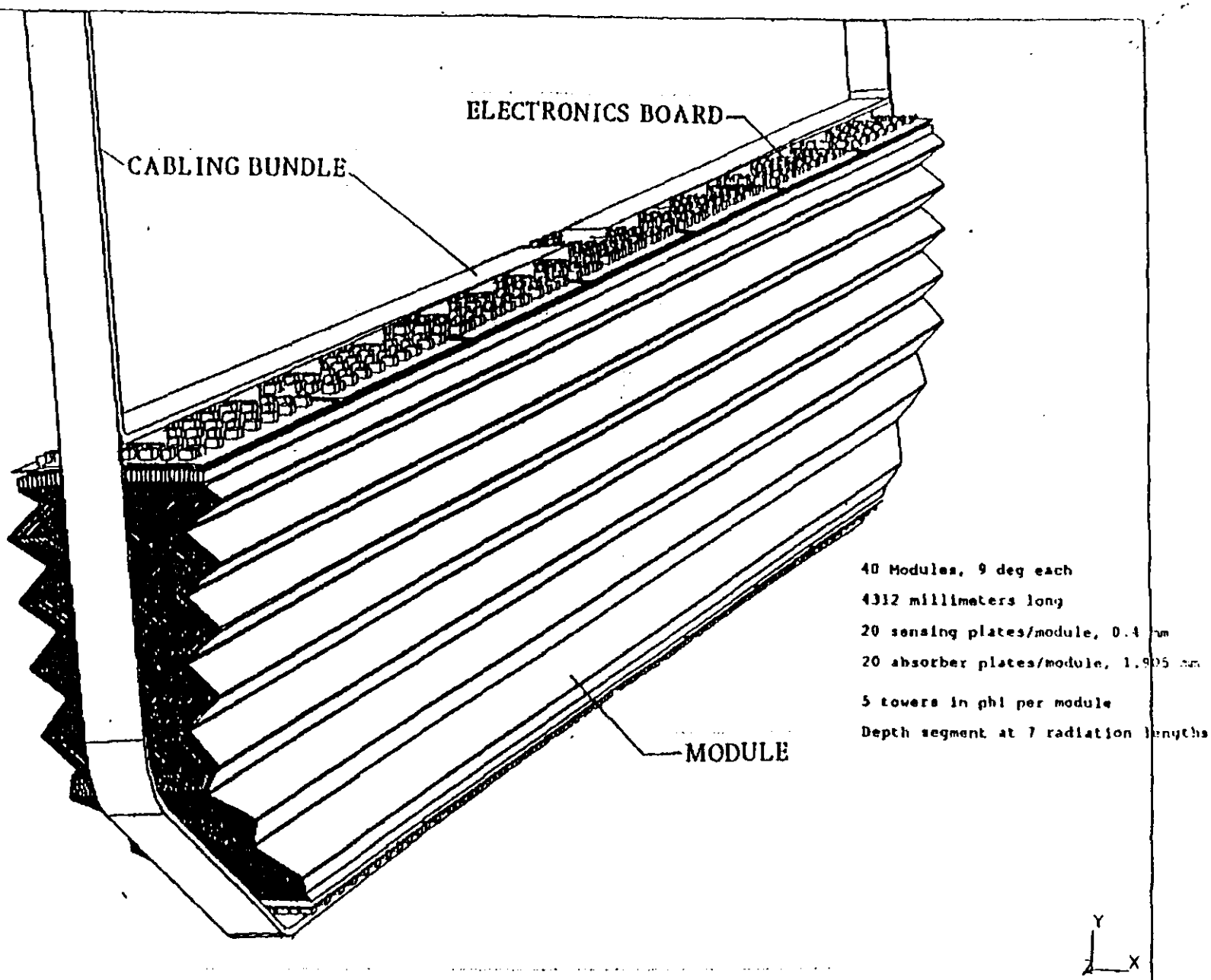
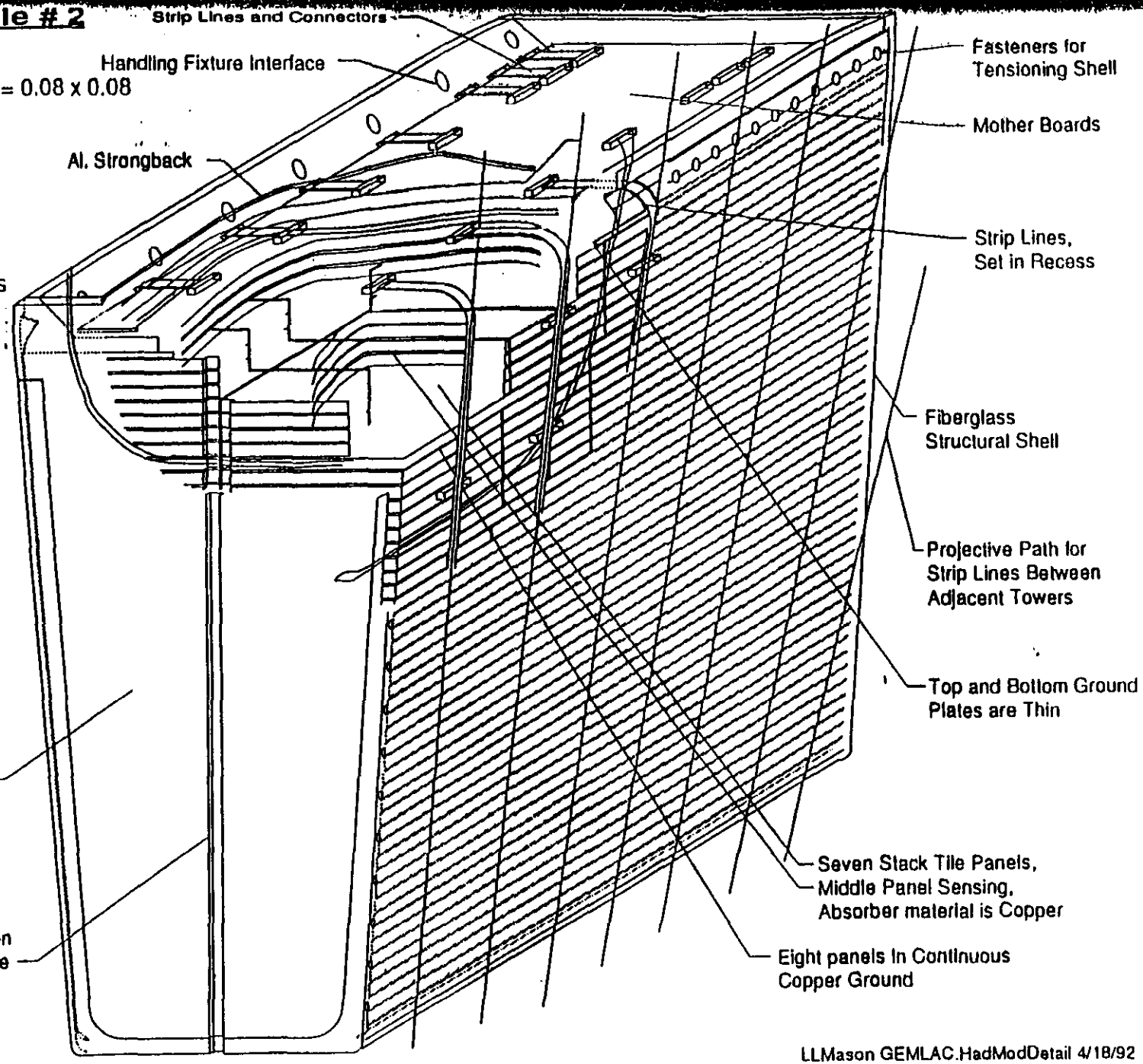


Figure 1-5 Assembled Module Showing Cabling Bundles

Hadron Module # 2

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



LLMason GEMLAC.HadModDetail 4/18/92

LIQUID ARGON CALORIMETER - HADRONIC MODULES

Radial dimension for confirming compatiability with the vessel are shown.
Maximum stack heights were used to compare with minimal vessel radii in Figure 2-1.
Ambient is 300K, Cold is 86K.

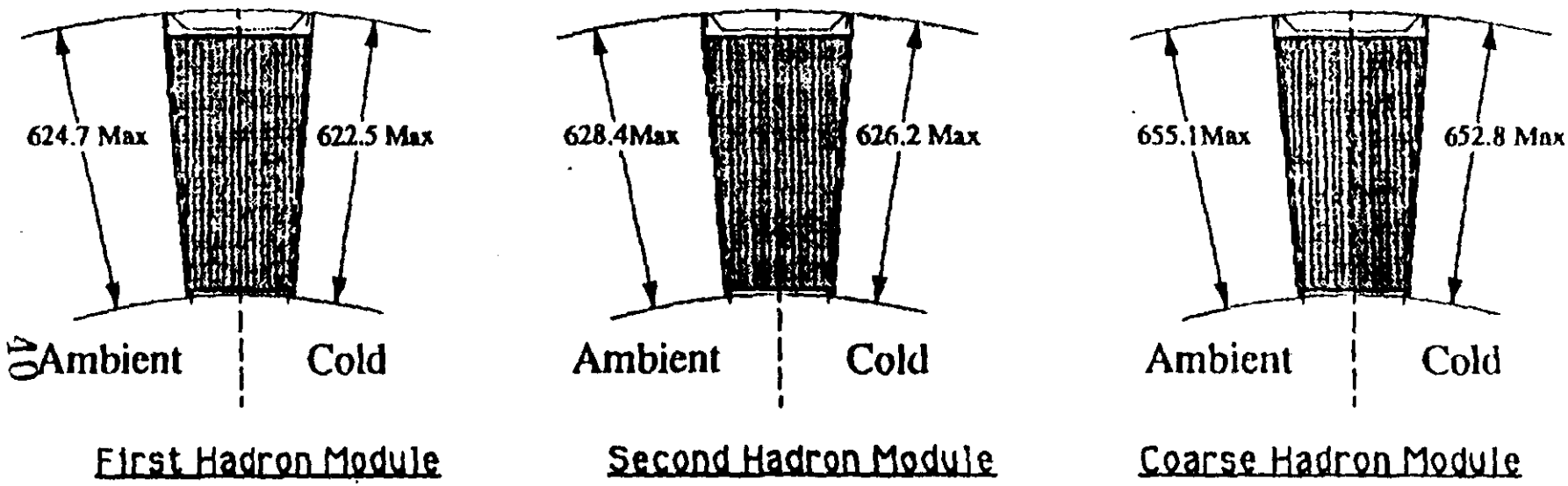


Figure 2-5. Radial Dimension - Thermal effects on Hadron Modules

All dimensions are in mm

MODULE TOLERANCE STACKUP

All Dimensions in mm

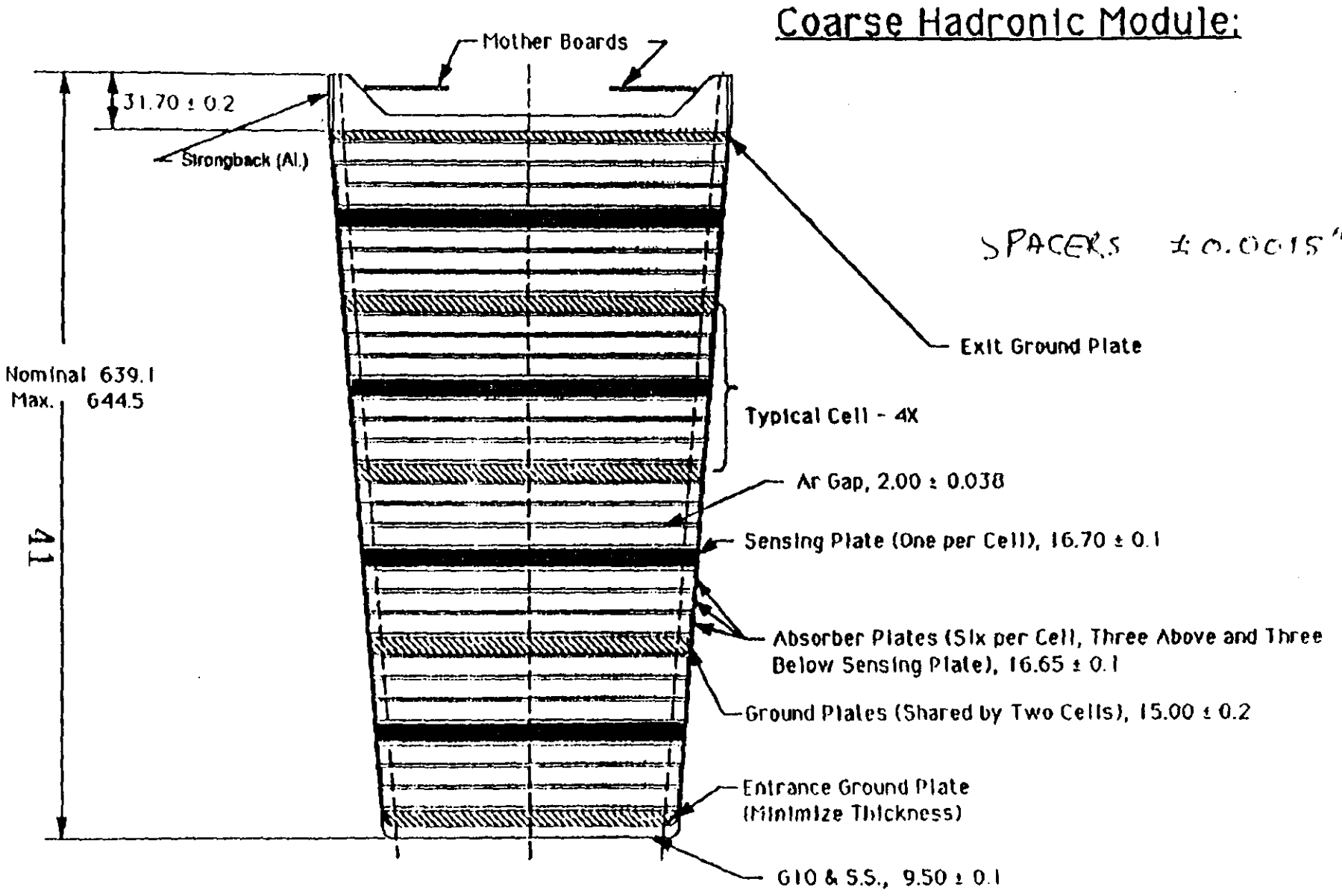


Figure 2-4. Coarse Hadron Module Showing Stack Height and Element Tolerances

KRBarnstable Module Tol C.H.#Fig2 4

TYPICAL ARGON VESSEL TOLERANCE STACKUP

Vessels are 5083 Aluminum

All Dimensions in mm

Module Max Radial Dimensions at Ambient and Cold

615.5max	EM Module Ambient
531.6max	EM Module Cold
524.7max	1st Fine Hadron Module Ambient
522.5max	1st Fine Hadron Module Cold
520.7max	2nd Fine Hadron Module Ambient
518.5max	2nd Fine Hadron Module Cold
549.7max	Coarse Hadron Module Ambient
547.4max	Coarse Hadron Module Cold

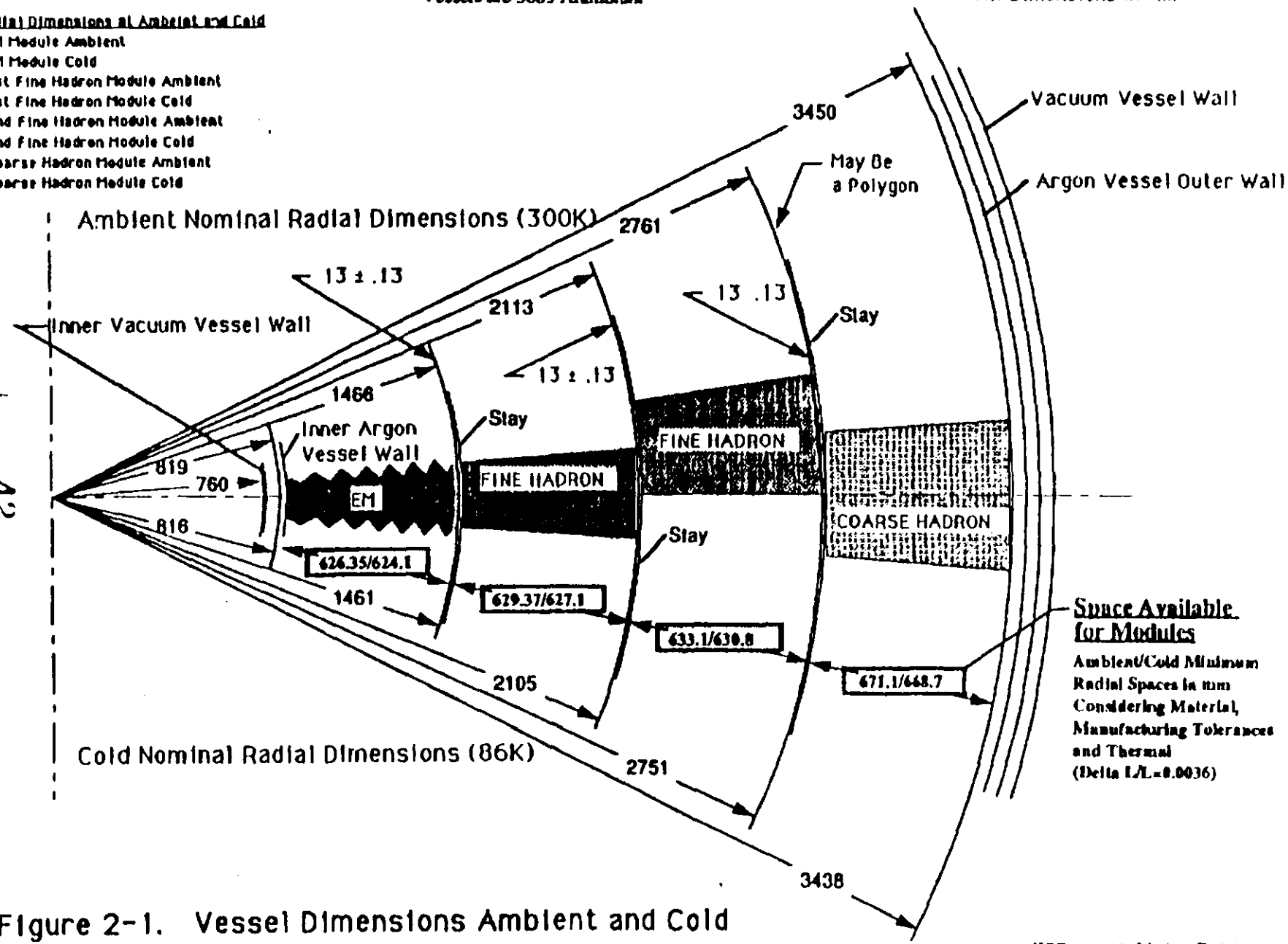


Figure 2-1. Vessel Dimensions Ambient and Cold

KRBarnstable Module Endview

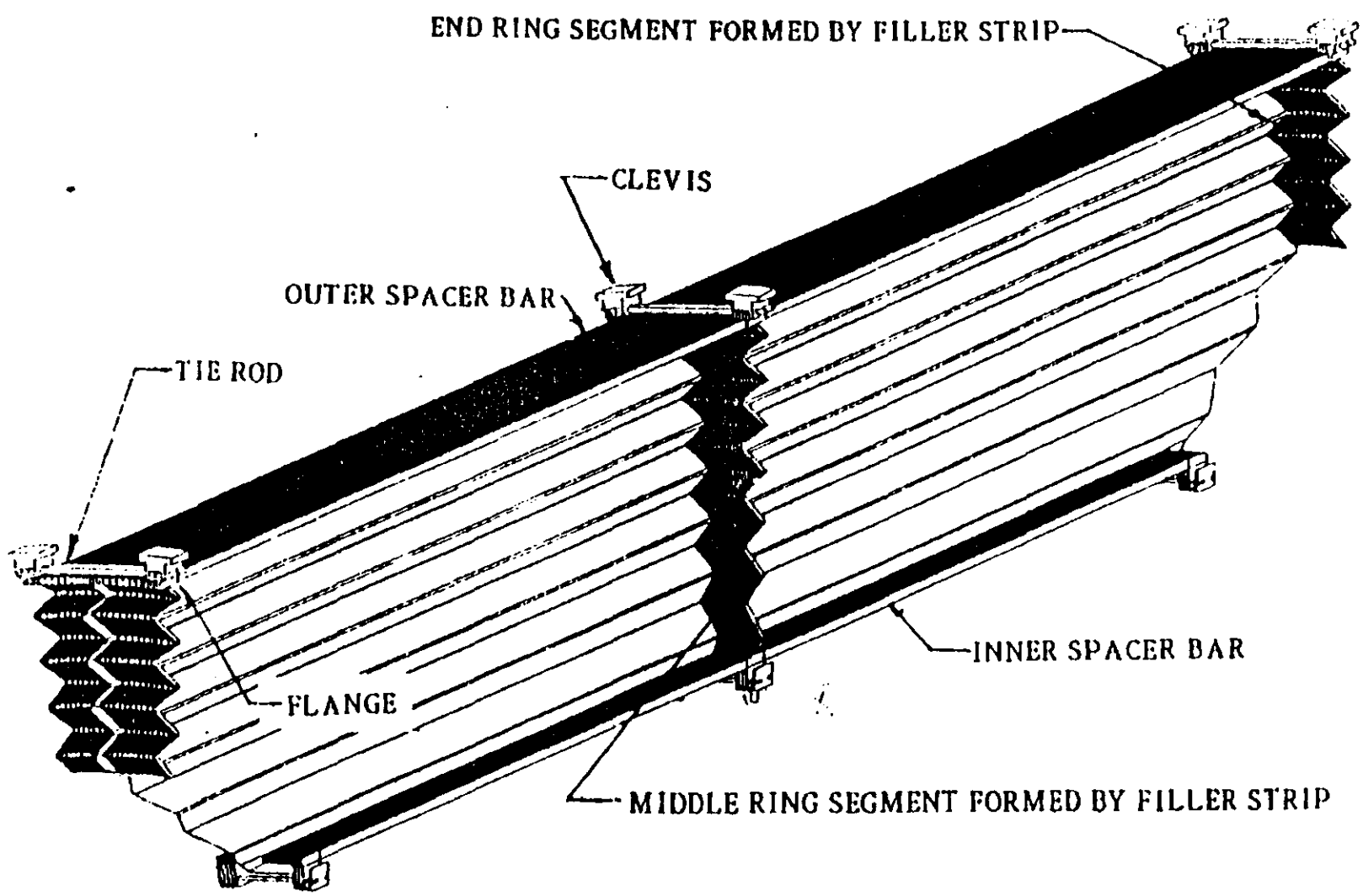
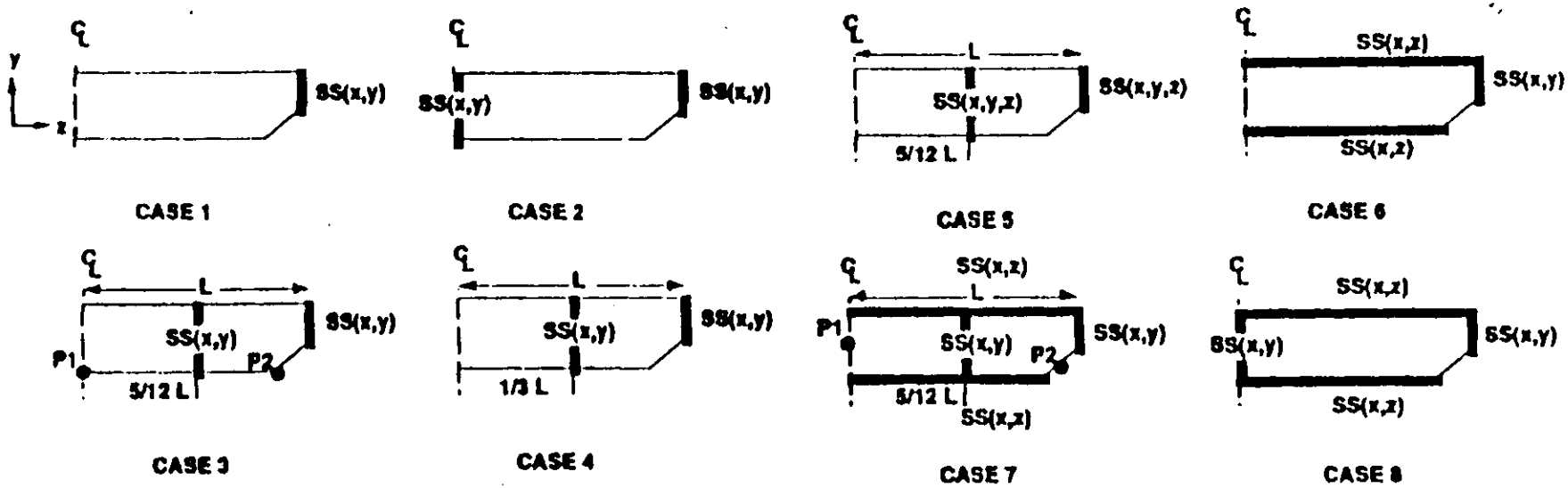


Figure 1-2b EM Module Structural Elements

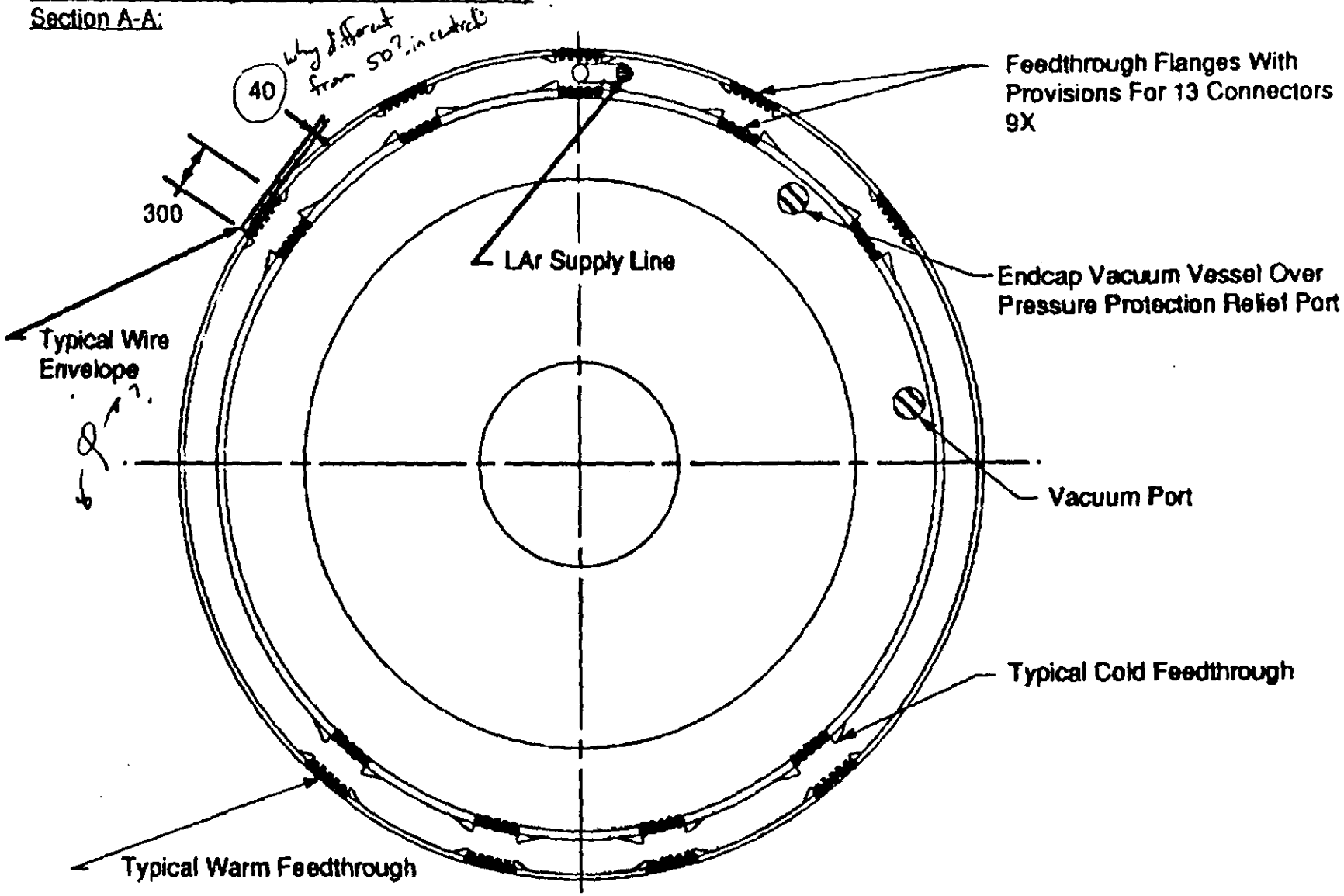


SS(x,y)	=	simply supported in x & y directions
SS(x,z)	=	simply supported in x & z directions
SS(x,y,z)	=	simply supported in x, y &z directions
P1, P2	=	locations for deflection measurements
L	=	half the length of the absorber plate

Figure 1-12 Support Cases 1-8

LIQUID ARGON CALORIMETER - Endview of Endcap

Endcap Feedthroughs - Cylinder Location Only ??
Section A-A:

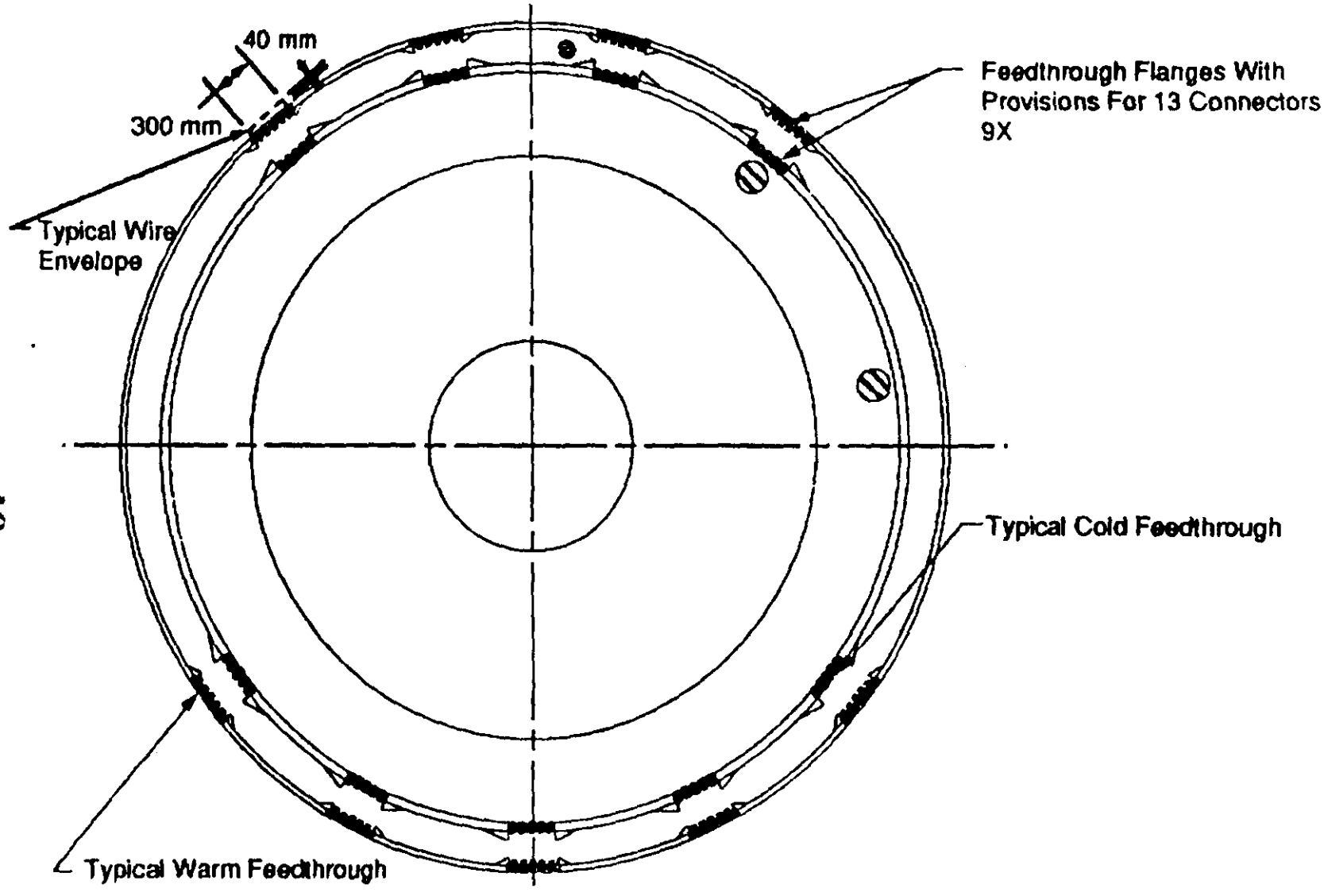


KRBarnstable BL1 E/C FT's Cyl Only

LIQUID ARGON CALORIMETER - Endview of Endcap

Endcap Feedthroughs - Cylinder Location Only.

Section B-B:



KRBarnstable BL1 E/C FT's Cyl Only

The 1992 GEM LAr/Kr Accordion Calorimeter Group

O. Benary, [9], S. Cannon, [5], W. Cleland[7],
I. Ferguson[2], C. Finley[5], A. Gordeev[6],
H. Gordon[3], E. Kistenev[3], P. Kroon[3],
M. Leltchouk[5], D. Lissauer[3], H. Ma[3],
D. Makowiecki[3], A. Maslennikov[4], S. McCorkle[3],
D. Onoprienko[6], A. Onuchin[4], Y. Oren[9],
V. Panin[4], J. Parsons[5], V. Radeka[3], L. Rogers[3],
D. Rahm[3], S. Rescia[3], J. Rutherfoord[2],
M. Seman[5], M. Smith[3], J. Sondericker III[3],
R. Steiner[1], D. Stephani[3], E. Stern[7], I. Stumer[3],
H. Takai[3], H. Themann[8], Y. Tikhonov[4]

[1] Adelphi University, Garden City, NY
[2] University of Arizona, Tucson, AZ
[3] Brookhaven National Laboratory, Upton, NY 11973
[4] Budker Institute for Nuclear Physics, Novosibirsk, Russia
[5] Columbia University, New York, NY
[6] Oak Ridge National Laboratory, Oak Ridge, TN
[7] University of Pittsburgh, Pittsburgh, PA
[8] SUNY at Stony Brook, Stony Brook, NY
[9] Tel-Aviv University, Tel-Aviv, Israel

The Liquid Argon Test.

Objectives:

1) EM energy resolution of 7.5% / $\sqrt{E}$ + 0.5%

1.3mm Pb Solution. Liquid Krypton. (Sampling fraction)

0.8 mm Pb in both absorber & readout electrode. (sampling frequency)

2) Position Resolution & e/π separation.

Chevron Design

3) Trigger.

Timing resolution (Bunch crossing), Trigger threshold,
Isolation efficiency.

4) Calibration.

New calibration system. 0.1-0.2 %

5) Electronic readout.

AMU – ZEUS electronics.
Track and hold.

6) Simulations.

Non projective geometry
Quasi projective
Projective geometry

7) Bending machine

Bending machine for Projective Geometry.

EM Configuration

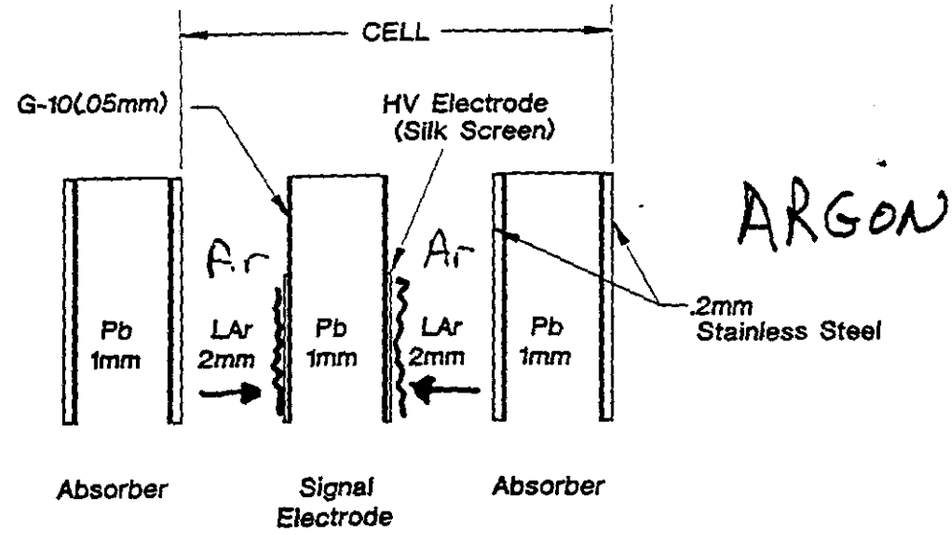
Goal $\leq 7.5\%/\sqrt{E}$

"1mm" option

increase sampling frequency

1mm OPTION

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



ARGON

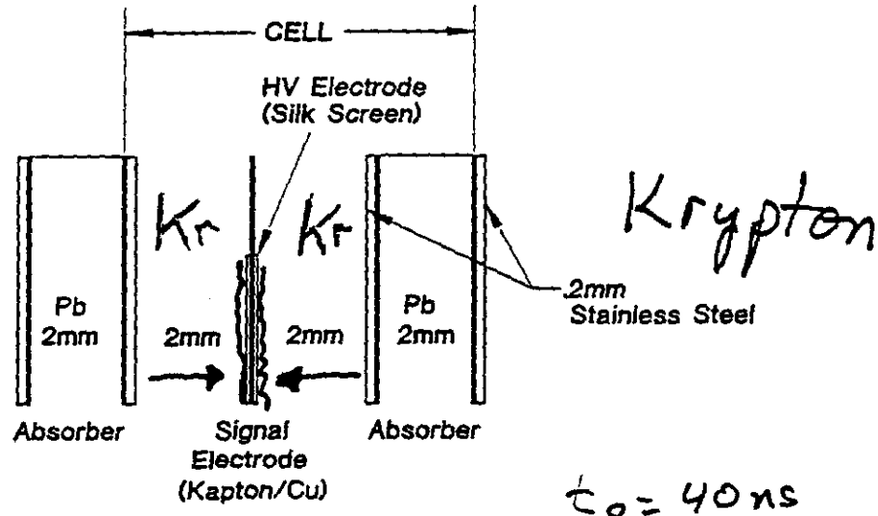
"2 mm" Option

decrease absorber thickness

increase sampling fraction

2mm OPTION

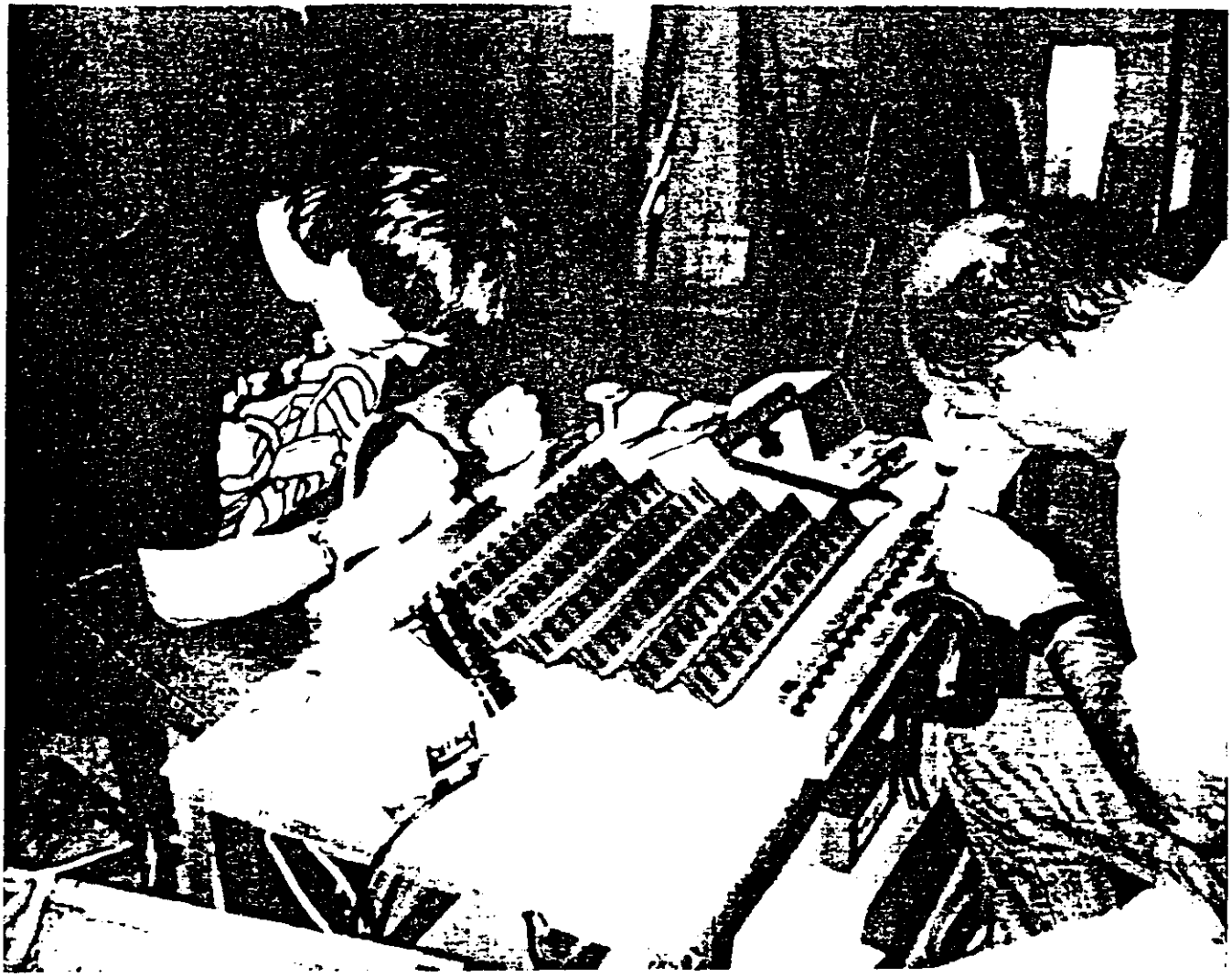
P=
X.=
Tt=
Rs=22.8%
Cell=6.6mm



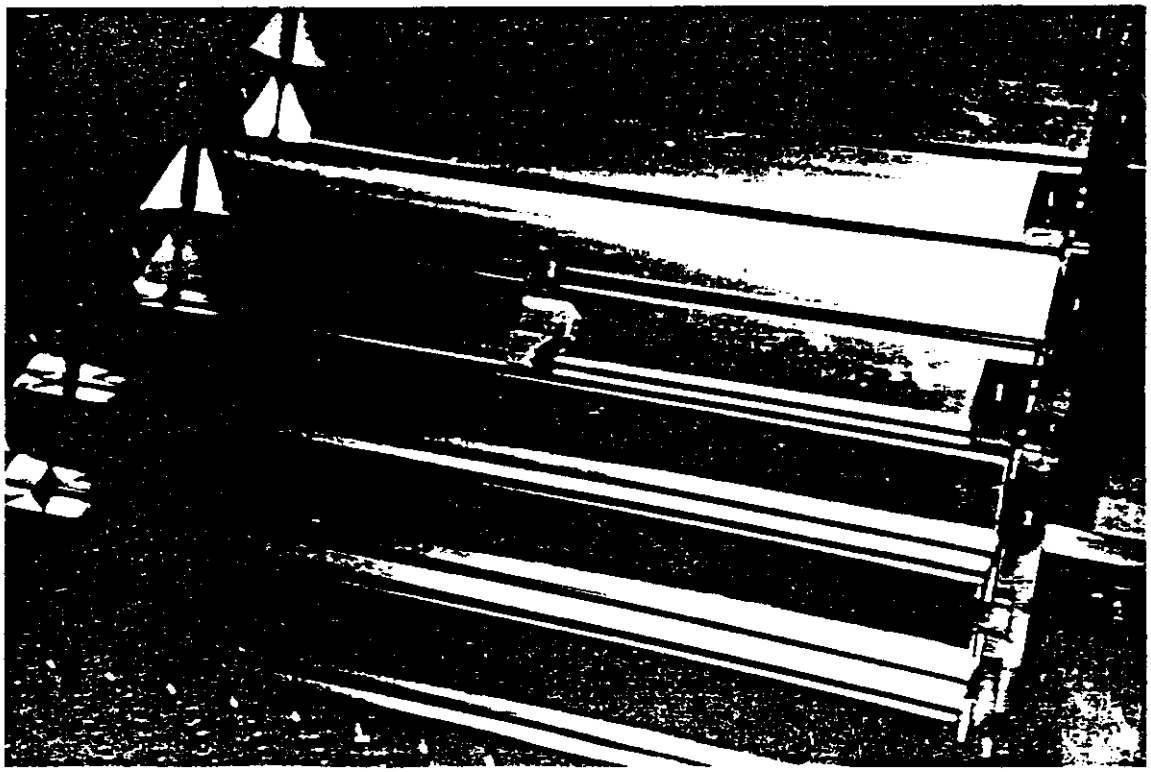
Krypton

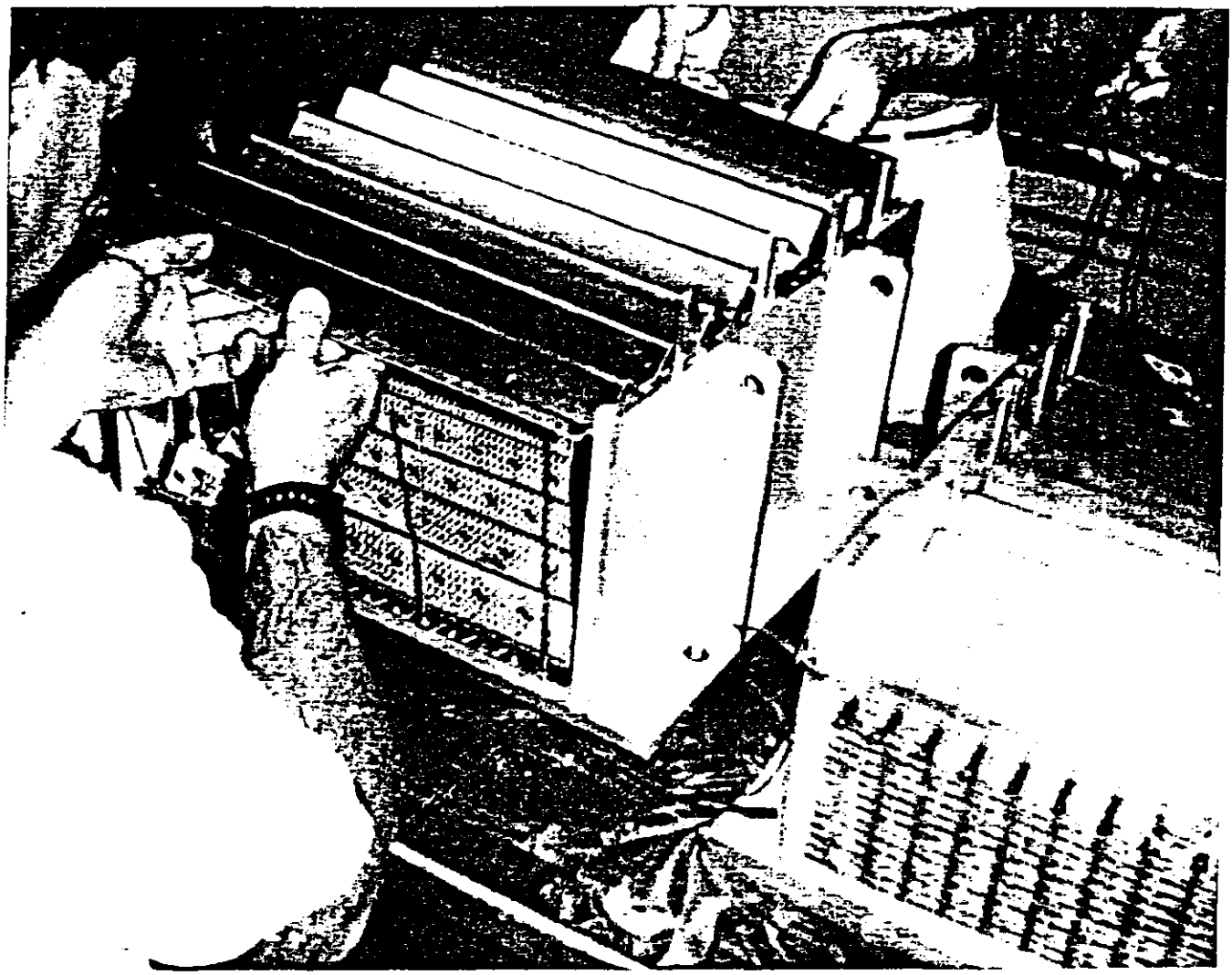
$t_p = 40ns$

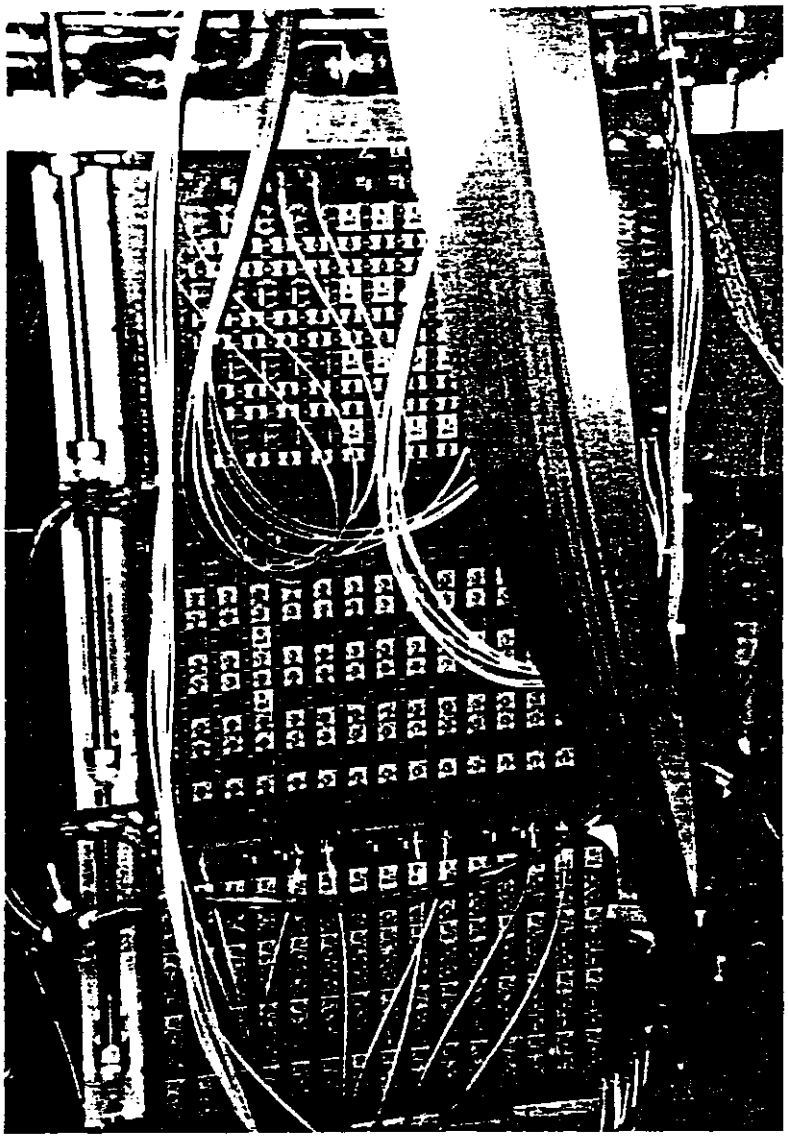
Goal [redacted] $\frac{7.5\%}{\sqrt{E}}$



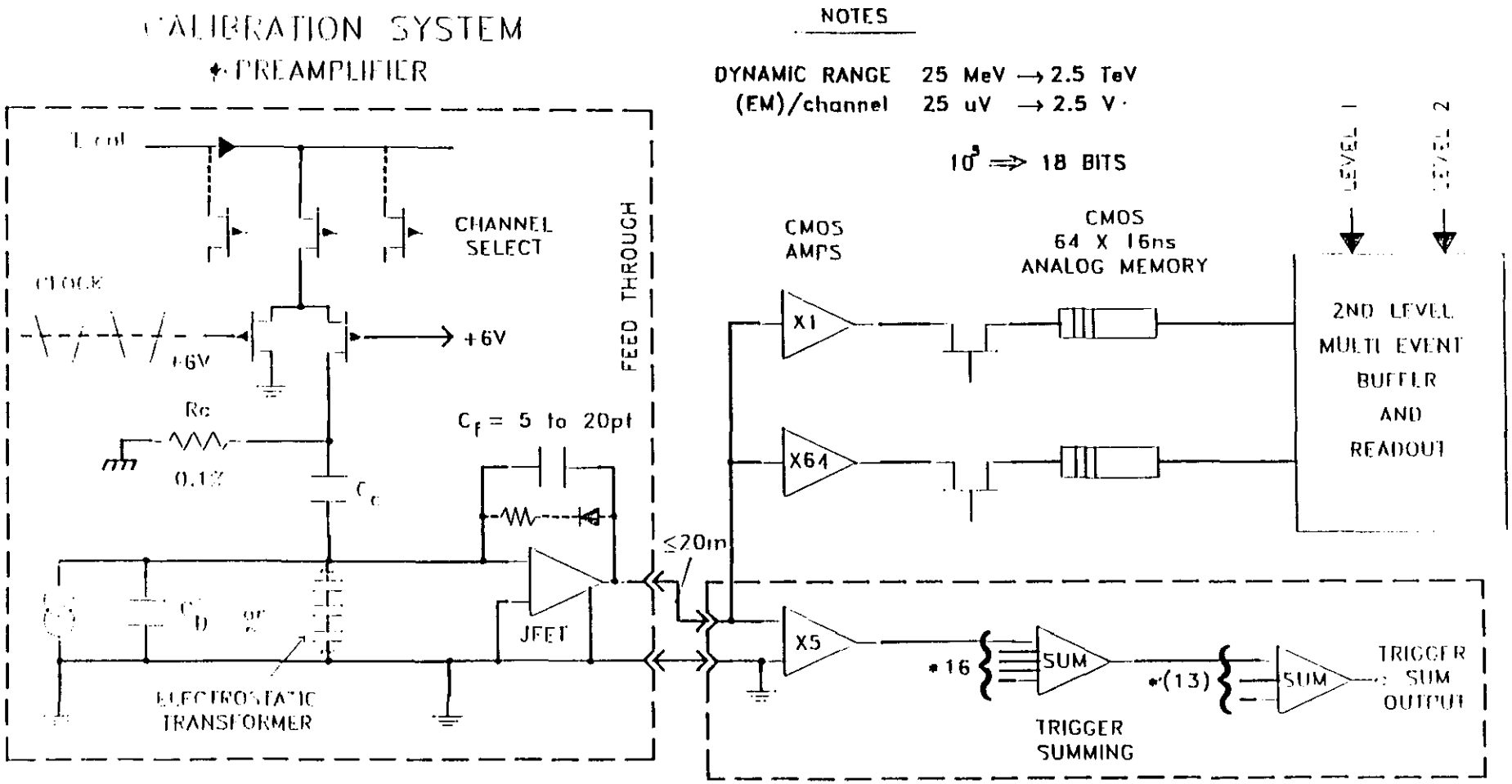
NIMBUS







20



BNL-OMEGA JMH
SSC LA CAL SSCT002

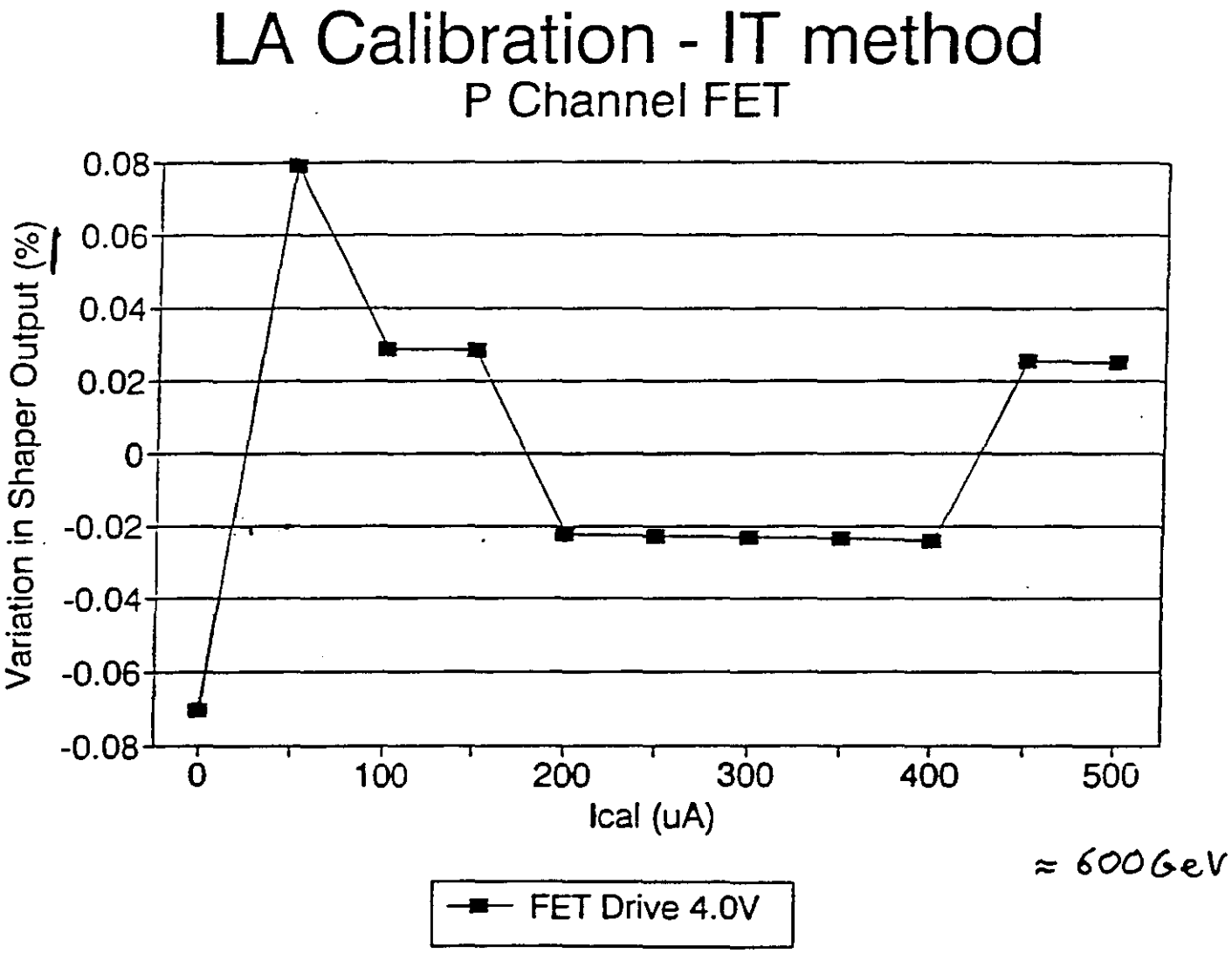
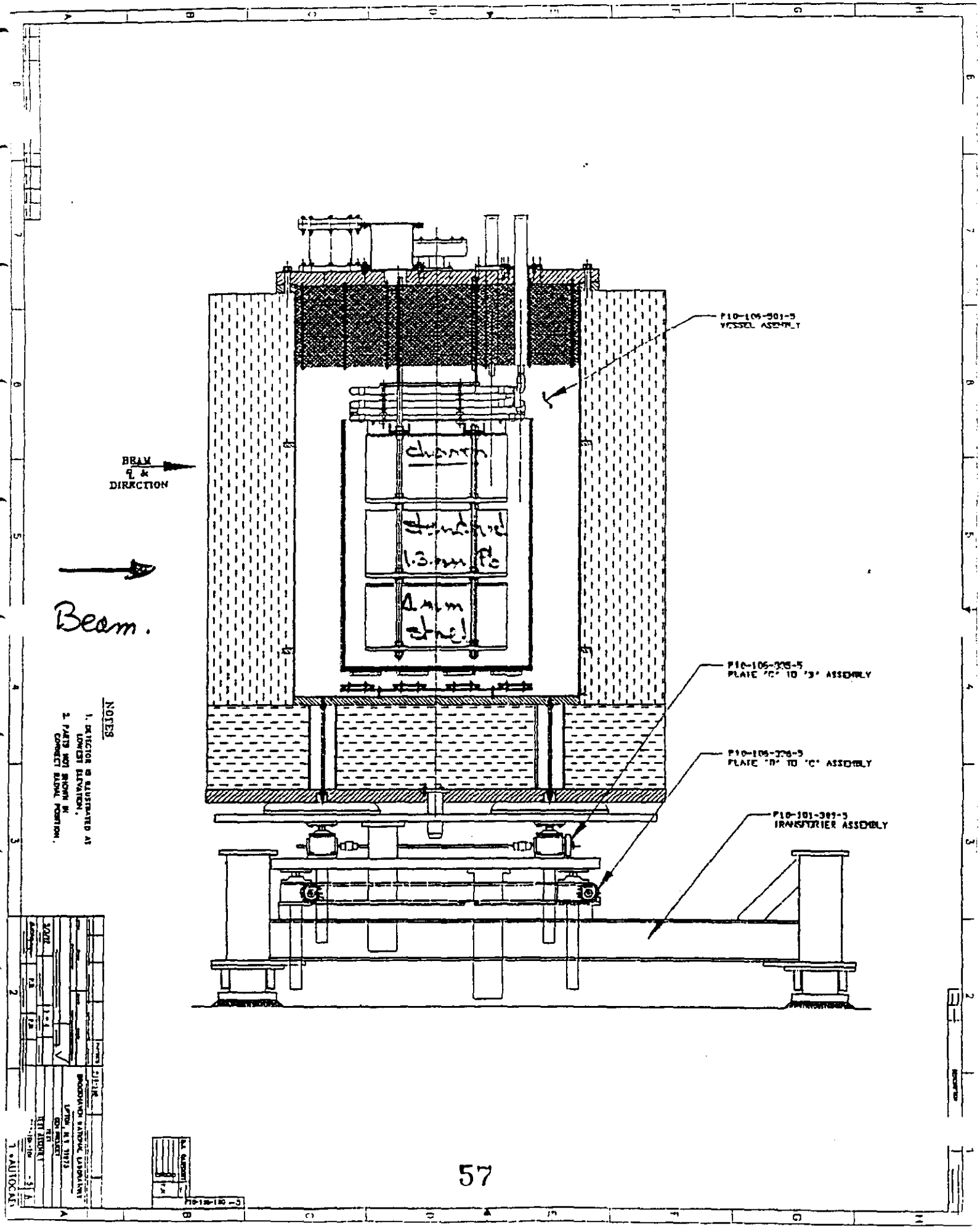
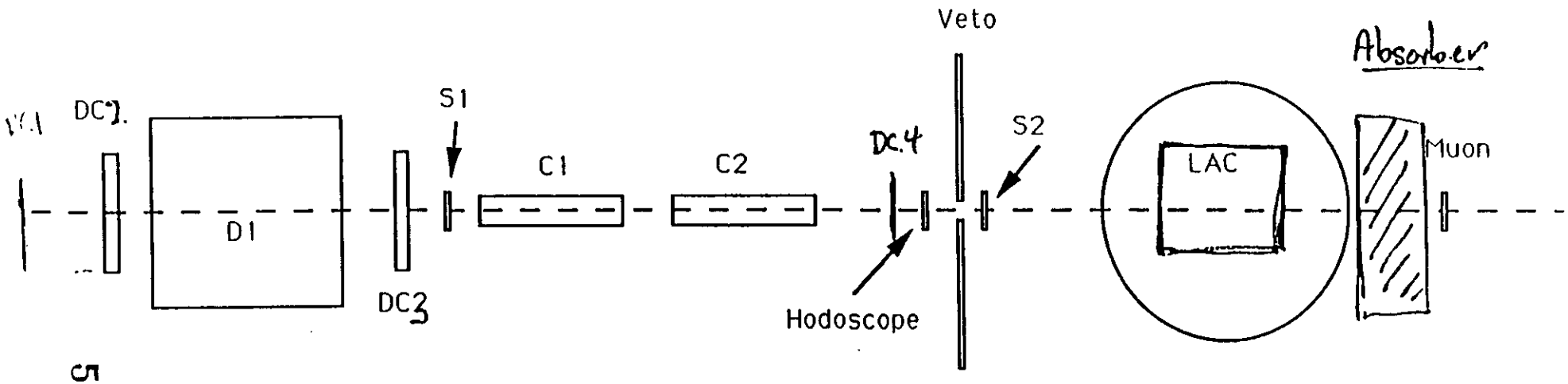

LA Calibration - IT method
P Channel FET
Variation in Shaper Output (%)
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
0
100
200
300
400
500
Ical (uA)
≈ 600 GeV
FET Drive 4.0V

Fig. 5


BEAM
℄
DIRECTION
Beam.
P10-106-501-5
VESSEL ASSEMBLY
P10-106-325-5
PLATE "C" TO "B" ASSEMBLY
P10-106-326-5
PLATE "B" TO "C" ASSEMBLY
P10-101-309-5
TRANSPORTER ASSEMBLY
NOTES
1. DETECTOR IS ILLUSTRATED AT LOWEST ELEVATION.
2. PARTS NOT SHOWN IN CORRECT AXIAL POSITION.
BROOKHAVEN NATIONAL LABORATORY
UPTON, N.Y. 11973
AUTOCAD

A3 – Beam Line: HGS.

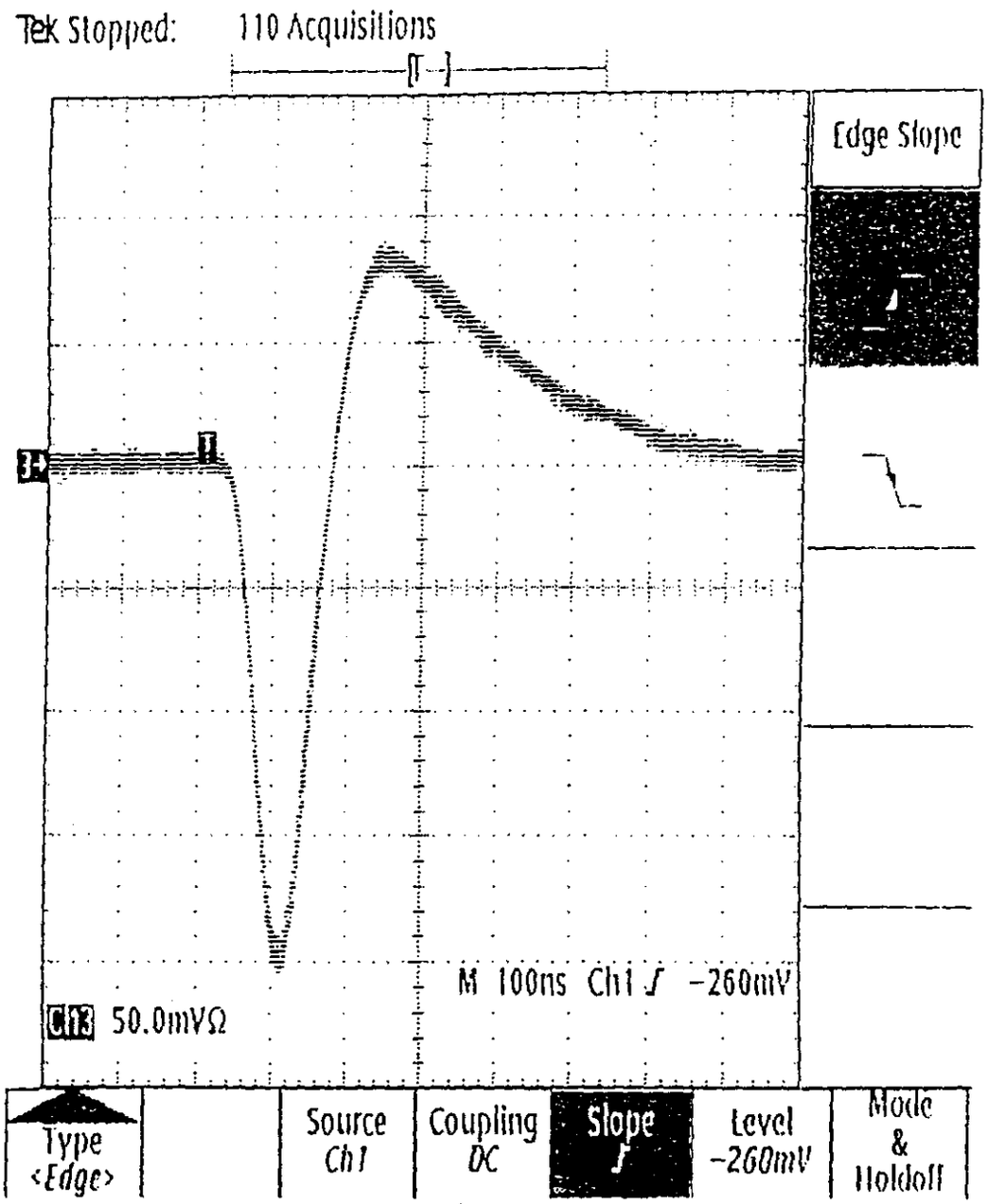


Beam: 0.5 Gev → 20 Gev

$\bar{p} / \pi / e^-$

$\sim 10^6$ pps.

7/22/92



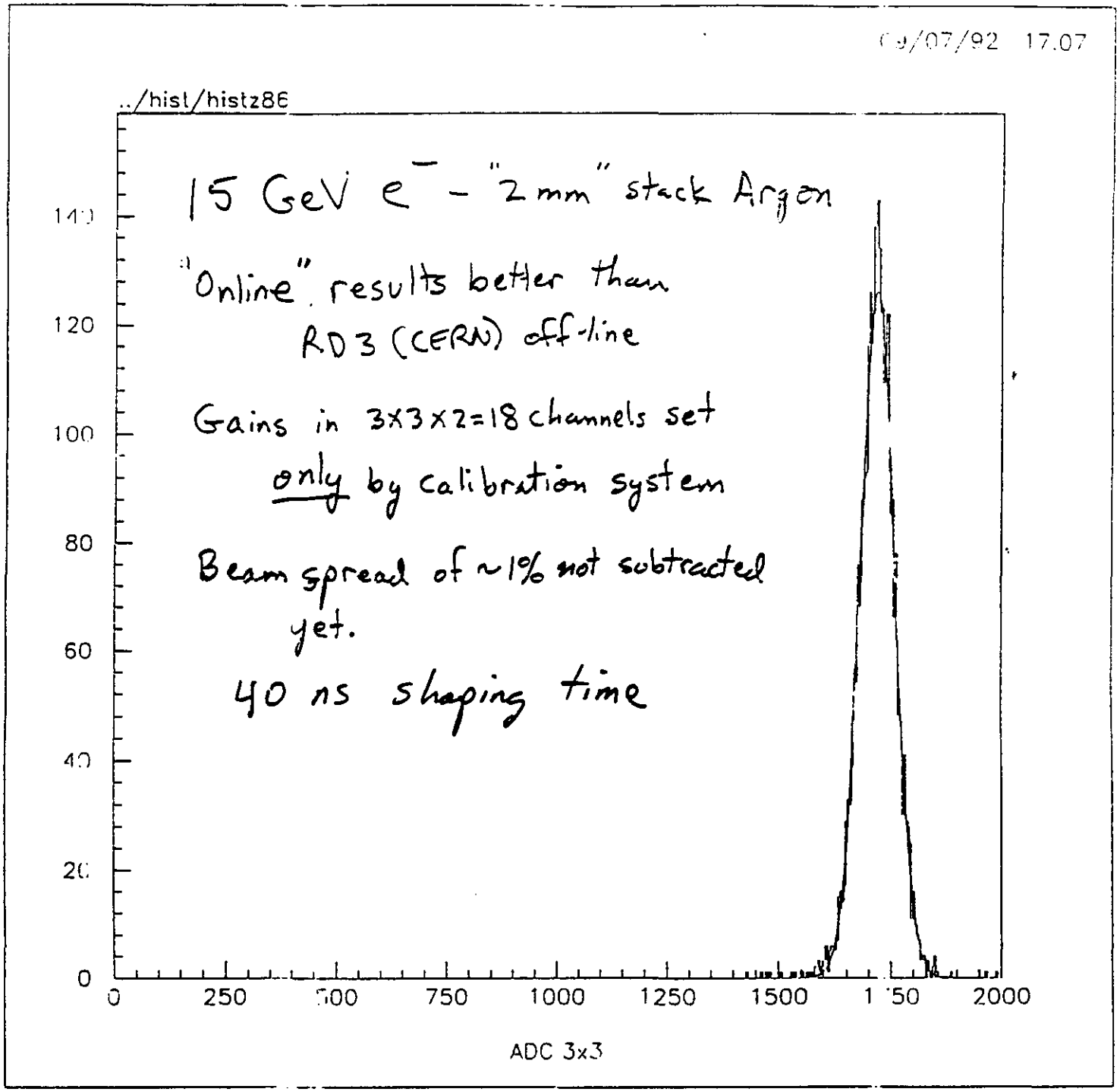
L Kr , 2 mm Stack , 1.5 kV

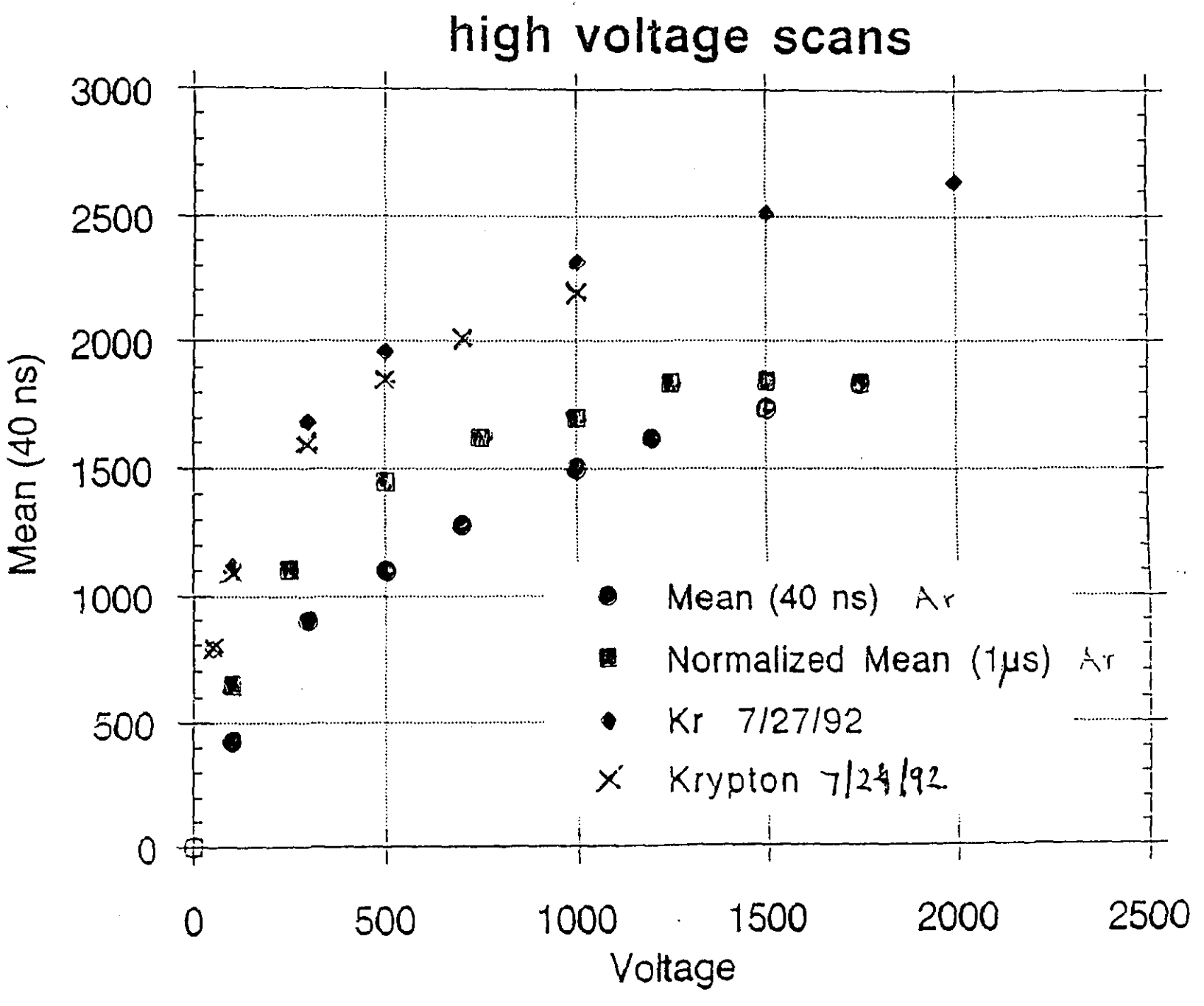
20GeV

Sum of ~150 channels

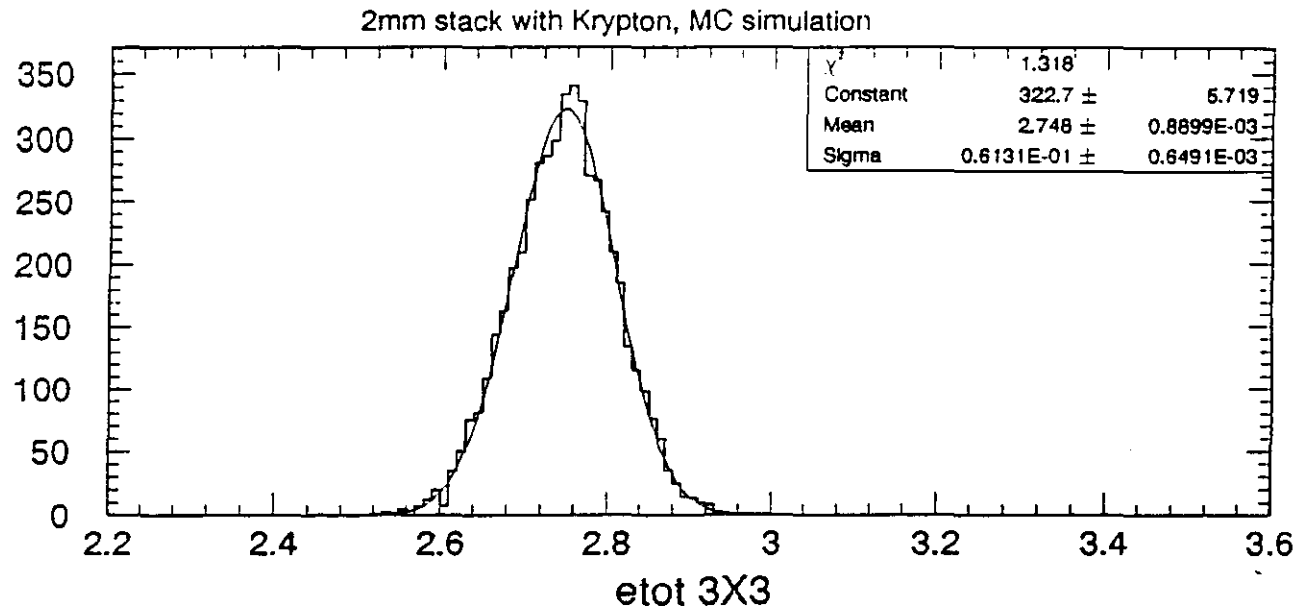
Multiple trace - variable persistence

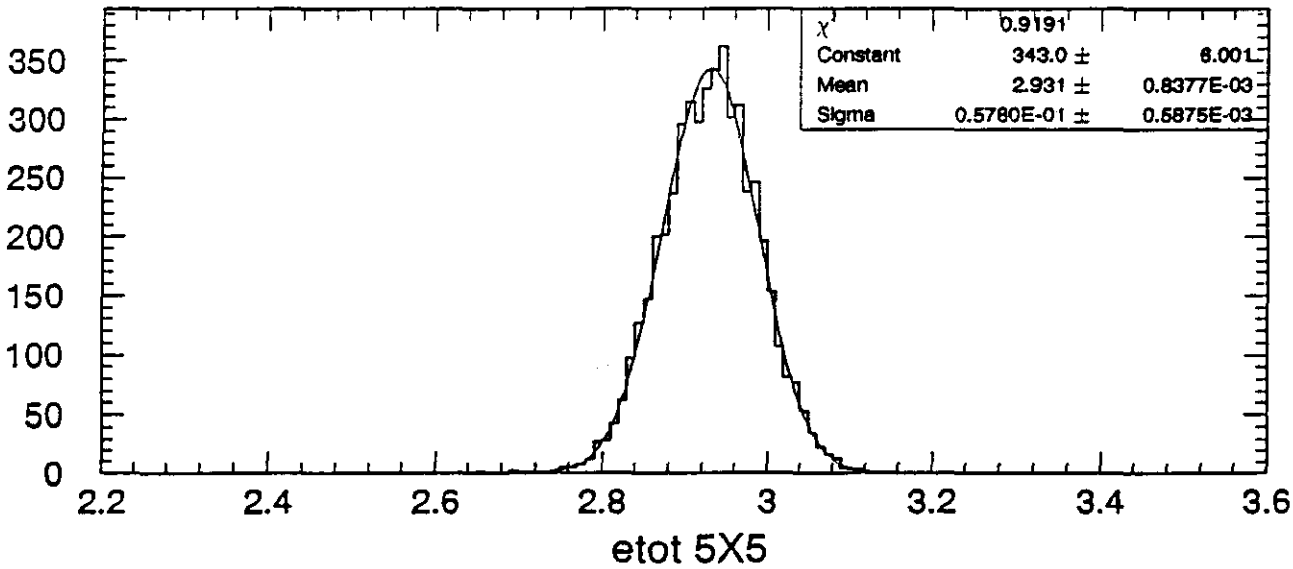
Beam size : 2.5 x 5 cm^2


09/07/92 17.07
../hist/histz86
15 GeV e⁻ - "2 mm" stack Argon
"Online" results better than
RD3 (CERN) off-line
Gains in 3x3x2=18 channels set
only by calibration system
Beam spread of ~1% not subtracted
yet.
40 ns shaping time
0
20
40
60
80
100
120
140
0
250
500
750
1000
1250
1500
1750
2000
ADC 3x3

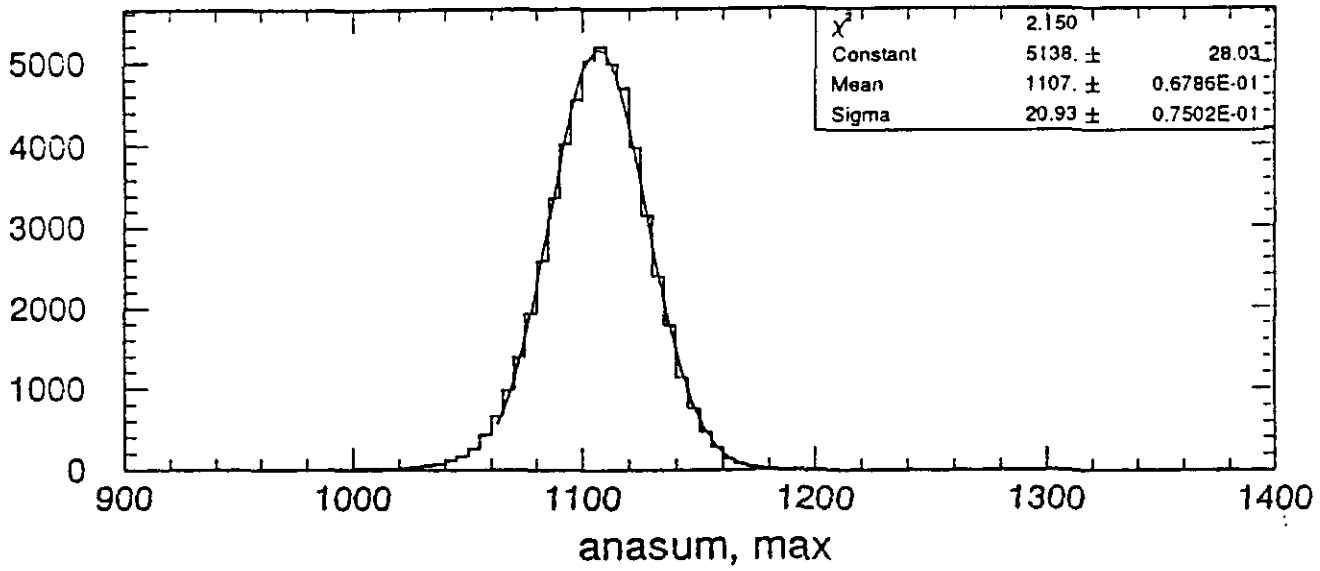

high voltage scans
Mean (40 ns)
Voltage
0
500
1000
1500
2000
2500
3000
Mean (40 ns) Ar
Normalized Mean (1μs) Ar
Kr 7/27/92
Krypton 7/24/92

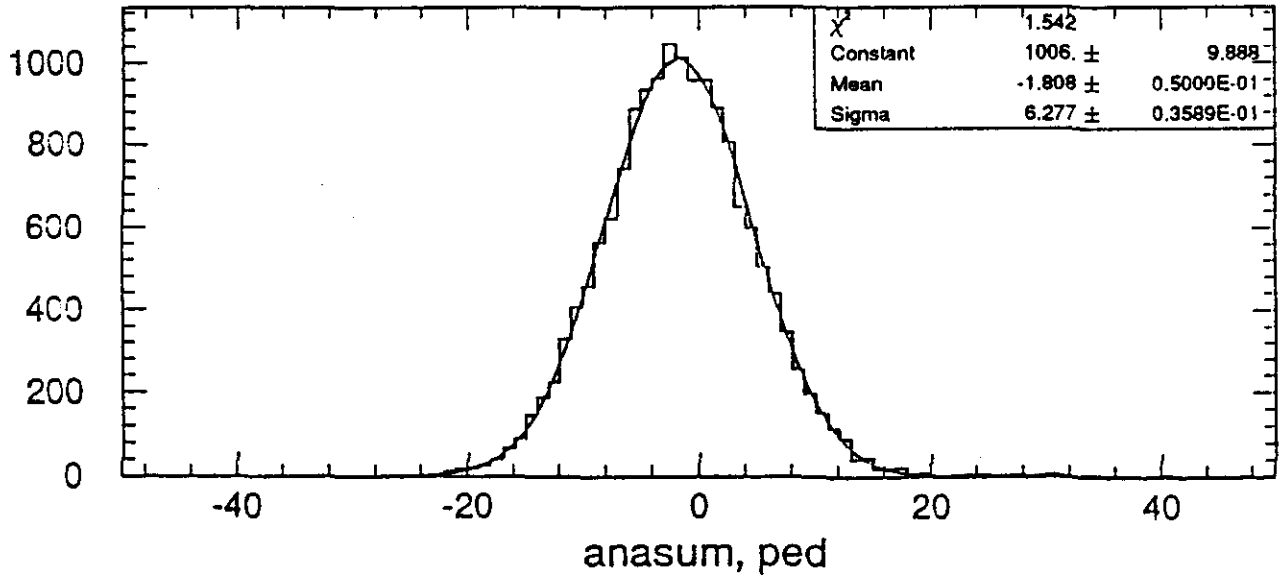
M.C: 3X3, 5X5 Krypton

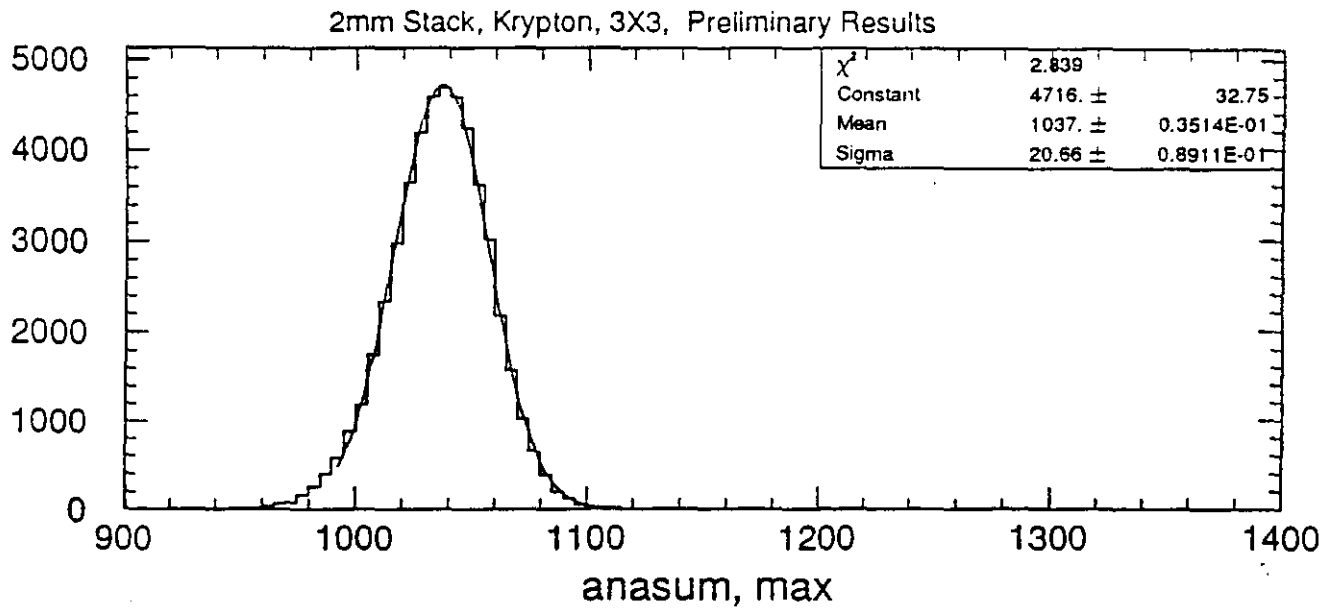


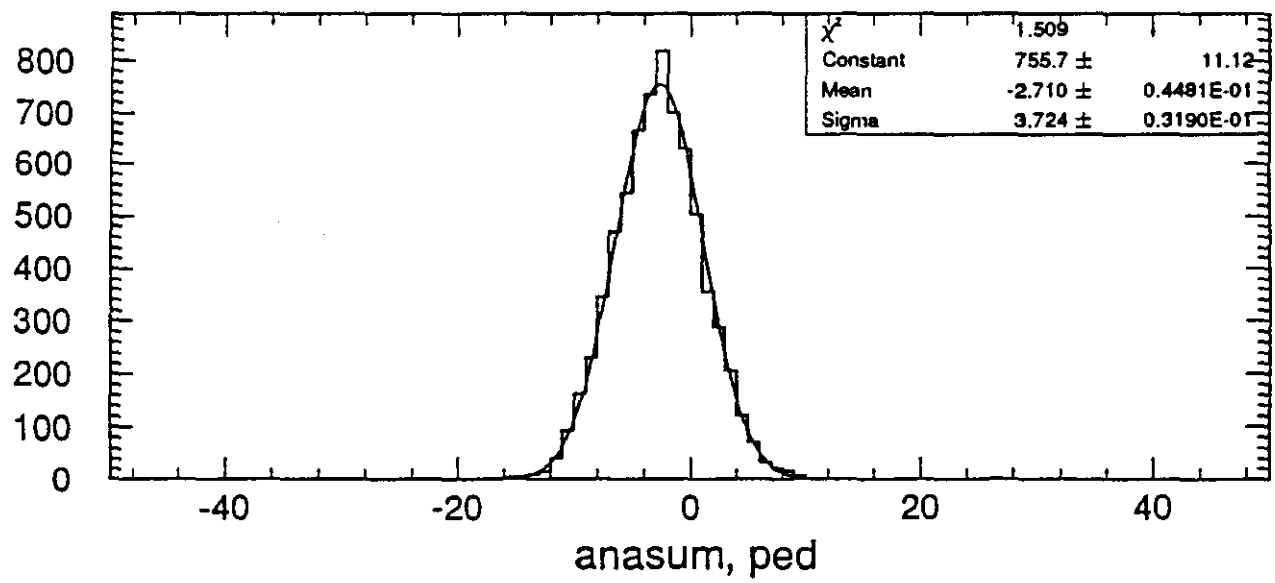


2mm Stack, Krypton, 5X5, Preliminary Results






2mm Stack, Krypton, 3X3, Preliminary Results
χ^2 2.839
Constant 4716. ± 32.75
Mean 1037. ± 0.3514E-01
Sigma 20.66 ± 0.8911E-01
5000
4000
3000
2000
1000
0
900
1000
1100
1200
1300
1400
anasum, max


χ^2 1.509
Constant 755.7 ± 11.12
Mean -2.710 ± 0.4481E-01
Sigma 3.724 ± 0.3190E-01
800
700
600
500
400
300
200
100
0
-40
-20
0
20
40
anasum, ped

Preliminary Results!!

$$\frac{\Delta E}{E} = \frac{a}{\sqrt{E}} \oplus \frac{b}{E} \oplus c$$

I: Standard L.A. Module.

M.C: $7.3\%/\sqrt{E}$

$$\frac{\Delta E}{E} = \frac{8\%}{\sqrt{E}} \oplus \frac{140}{E} \oplus 0$$

$\frac{\Delta P}{P} = 0.5 - 0.7\%$

$$\frac{\Delta E}{E} = \frac{7.5 - 7.8\%}{\sqrt{E}} \oplus \frac{140}{E} + 0$$

II 1 mm L.A.

m.c $6.25\%/\sqrt{E}$

$$\Delta E/E = 6.4\%/\sqrt{E} \oplus 240/E \oplus 0$$

$\frac{\Delta P}{P} = 0.5 - 0.3\%$

$$\Delta E/E = 6\%/\sqrt{E} \oplus 240/E \oplus 0.$$

Krypton. —

Preliminary !!

3X3 m.c: $7.11\%/\sqrt{E}$

$$\frac{\Delta E}{E} = \frac{7.56\%}{\sqrt{E}} \oplus \frac{53}{E} + 0$$

$$\frac{\Delta P}{P} = 0.5 - 0.7\%$$

$$\frac{\Delta E}{E} = \frac{7 - 7.3\%}{\sqrt{E}} \oplus \frac{53}{E} + 0$$

5X5: m.c: $6.3\%/\sqrt{E}$

$$\frac{\Delta E}{E} = \frac{6.9}{\sqrt{E}} \oplus \frac{85}{E} \oplus 0$$

$$\frac{\Delta P}{P} = 0.5 - 0.7\%$$

$$\frac{\Delta E}{E} = \frac{6.3 - 6.9}{\sqrt{E}} \oplus \frac{85}{E} \oplus 0$$

NOISE CALCULATIONS + MEASUREMENTS for LAr/Kr Calorimetry

(still evolving)

(In consultation with W. E. Cleland, V. Radeka, S. Rescia & E. Stern)

1) Measurement of thermal noise in "2mm" Accordion Tests

$t_p = 40\,ns$ 1.75 kV, Ar not completely pure

		Baseline I	3×3	5×5
Ar	35 MeV/Tower	28	105	175
Kr	20 MeV/Tower		60	100

1.5 kV not pure

1) dE/dx higher than Ar
2) preamp noise lower @ 120K

2) Cleland and Stern find $\sigma_E = 1.5\,GeV\,(A)^{0.76}$

$$A = \Delta\eta \times \Delta\varphi$$

eg $R = 0.6$ for "32ns gate" $\sigma_E = 3.3\,GeV$

3) $\sigma_T = \sqrt{\sigma_{TH}^2 + \sigma_{PU}^2}$ $\quad \sigma_{TH} \sim (1/t_p)^{3/2}$, $\sigma_{PU} = \sigma_E \sqrt{F_2 P/16\,ns}$

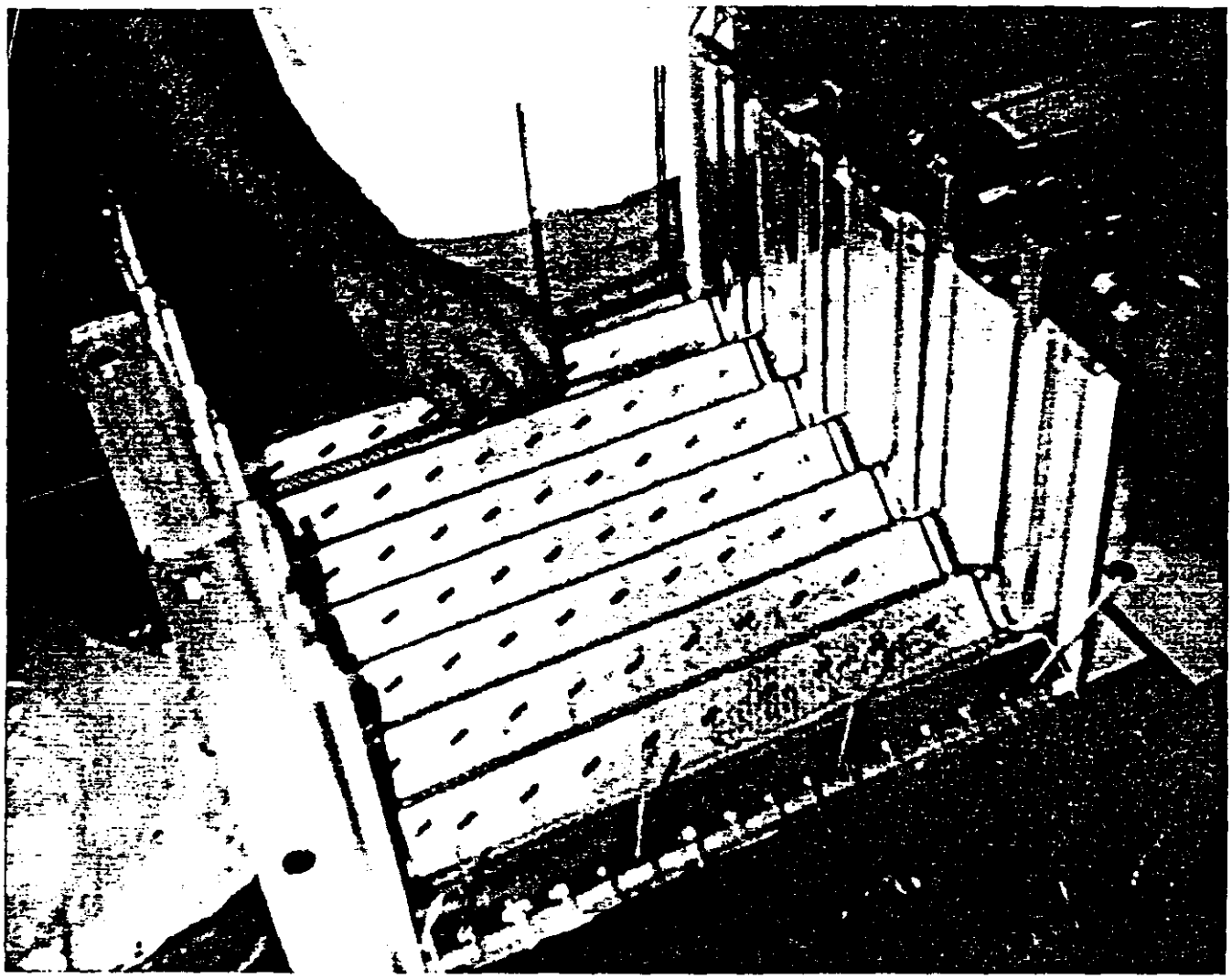
$\sim t_p^{1/2}$

σ_T (GeV) (t_p)(ns)

	Ar	Kr
0.08×0.15	0.154 (140)	0.128 (100)
R = 0.45	3.8 (80)	3.14 (60)
R = 0.60	5.7 (80)	4.6 (50)

Results Forthcoming (Sept.)

- Response versus Energy
- Position and angular resolution
- Timing precision (10 ns GeV)
- 18 ns pipeline readout
- uniformity – different cells
- HV dependence of resolution
- e/π rejection
- e/μ



gem

γeμ

Presentation by:

Harvey Newman

Newman

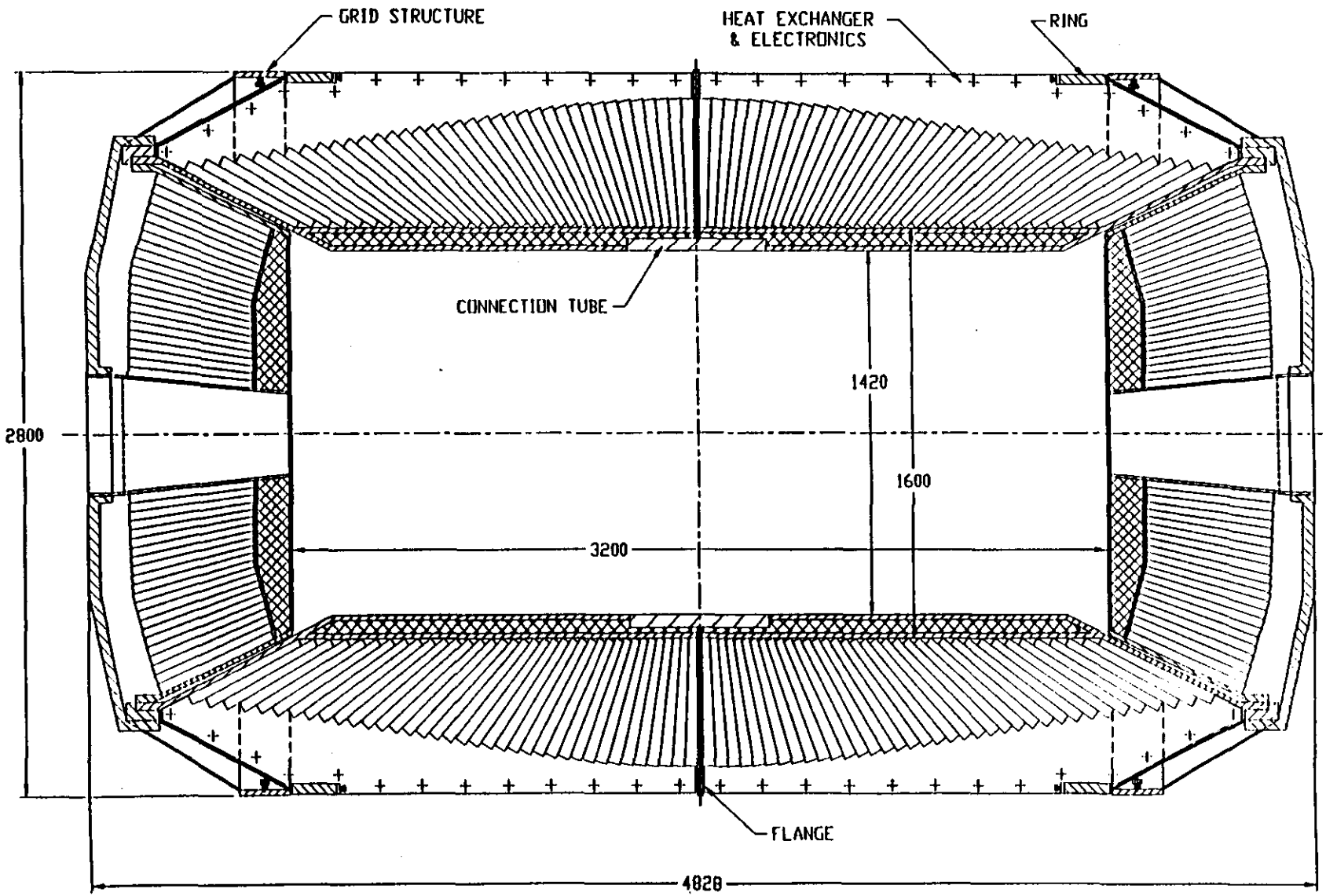
A PRECISION BaF_2 CRYSTAL CALORIMETER FOR GEM AT THE SSC

PROGRESS REPORT

California Institute of Technology
University of California, San Diego
Princeton University
Carnegie Mellon University
Brookhaven National Laboratory
Oak Ridge National Laboratory
Lawrence Livermore National Laboratory
Shanghai Institute of Ceramics
Beijing Glass Research Institute
Institute of HEP, Beijing
University of Science and Technology, Hefei
Tongji University, Shanghai
Tsinghua University, Shanghai
Zhongnan Optical Instrument Factory
Tata Institute of Fundamental Research, Bombay

GEM Collaboration Council

August 5, 1992



A. SMIRNOV

GEM DETECTOR
EM BaF2 Design

7/22/92

Growing collaboration

BaF_2 PRECISION EM CRYSTAL CALORIMETER

110 → 200+ Collaborators

NEW MAJOR R&D PARTNERS

- **LLNL**
  - Crystal Mass Production Process Design and Engineering
  - Surface Preparation
  - UV Reflective Coating
  - Pure Rad Hard Crystal Growth
- **ZHONGNAN OPTICAL INSTRUMENT FACTORY**
  - Crystal Mechanical Processing
  - Production UV Coating With BGRI
- **TSINGHUA UNIVERSITY**
  - MechanicaL Support
  - Multipoint Inspection Machine
  - Readout Electronics

+ R&D: • St. Petersberg Nuclear Physics Institute (SbXPI)
• Moscow Engineering Physics Institute (MEPhI)

BaF_2 EM CALORIMETER REQUIREMENTS FOR 8/92 GEM DECISION:

- DEMONSTRATE CAPABILITY TO MAINTAIN THE HIGH RESOLUTION IN SITU

- RADIATION HARD CRYSTALS*

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

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

- LIGHT COLLECTION UNIFORMITY**

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

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

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

(4) Cosmic Ray Measurements With Transverse Muons

* Self Annealing Study

** Longitudinal Segmentation Study (APD)

BaF_2 EM CALORIMETER
1992 R&D PROGRAM

- BaF_2 CRYSTAL PRODUCTION:
  (SIC, BGRI)

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

- UV MONITORING SYSTEM:
  (CMU,UCSD)

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

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

- PROTOTYPE ELECTRONIC READOUT
  (ORNL, PRINCETON)

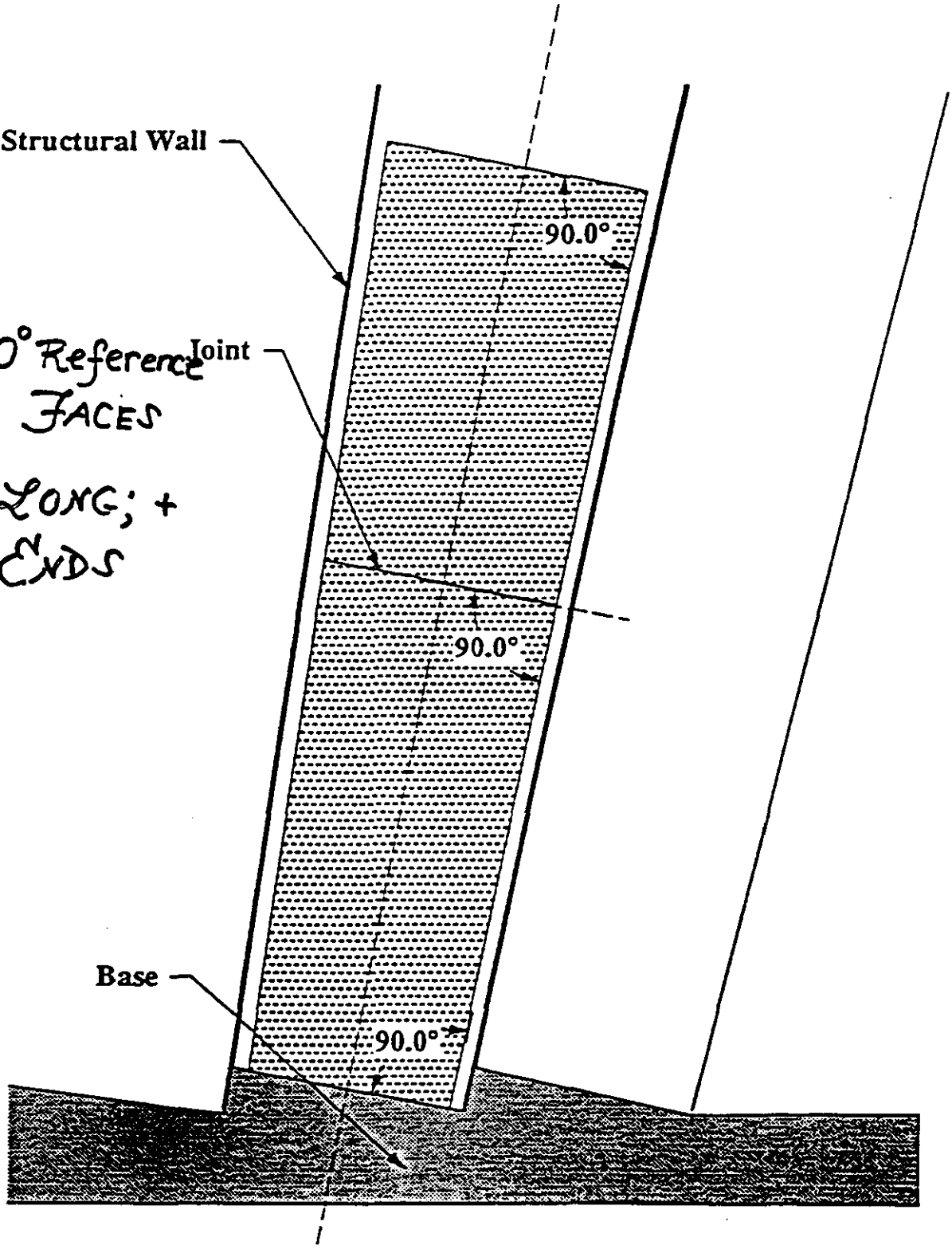
- CALIBRATION, UNIFORMITY, STABILITY:
  COSMIC RAY STAND; RFQ SYSTEM:
  (UCSD, CALTECH)

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

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

BaF_2 R&D PROGRESS
JULY, 1992

- PRODUCTION of LARGE RAD HARD CRYSTALS in CHINA (SIC, BGRI)
- SMALL ULTRA-PURE CRYSTAL GROWTH AT LLNL, OPTOVAC
- CRYSTAL MANUFACTURING IN CHINA: SIC, BGRI, ZHONGNAN, TSINGHUA
- LLNL and ORNL: MECHANICAL PROCESS ENGINEERING. TECHNOLOGY TRANSFER.
- UNIFORMITY: GRADED UV COATING (LLNL) – TECHNOLOGY TRANSFER: ZHONGNAN, BGRI
- BEAM TEST of BaF_2 MATRIX (FNAL)
- CRYSTAL STABILITY TESTS OVER 7-9 MONTHS
- NEUTRONS TO $7 \times 10^{13}/cm^2$: LITTLE EFFECT
- HADRON IRRADIATION TESTS AT AGS
- CALIBRATION: UV MONITORS, RFQ SYSTEM
- COSMIC RAY TEST STAND
- TRACE ELEMENT and MICROANALYSIS (CE&A)
- RADIATION DAMAGE MECHANISM STUDIES AT TONGJI, WEST VA. UNIVERSITY
- SIMULATION STUDIES: CALIBRATION, UNIFORMITY, PHOTON POINTING
- AVALANCHE PHOTODIODE + LONGITUDINAL SAMPLING OPTION (UNDER STUDY)
- PRE-IRRADIATION OPTION



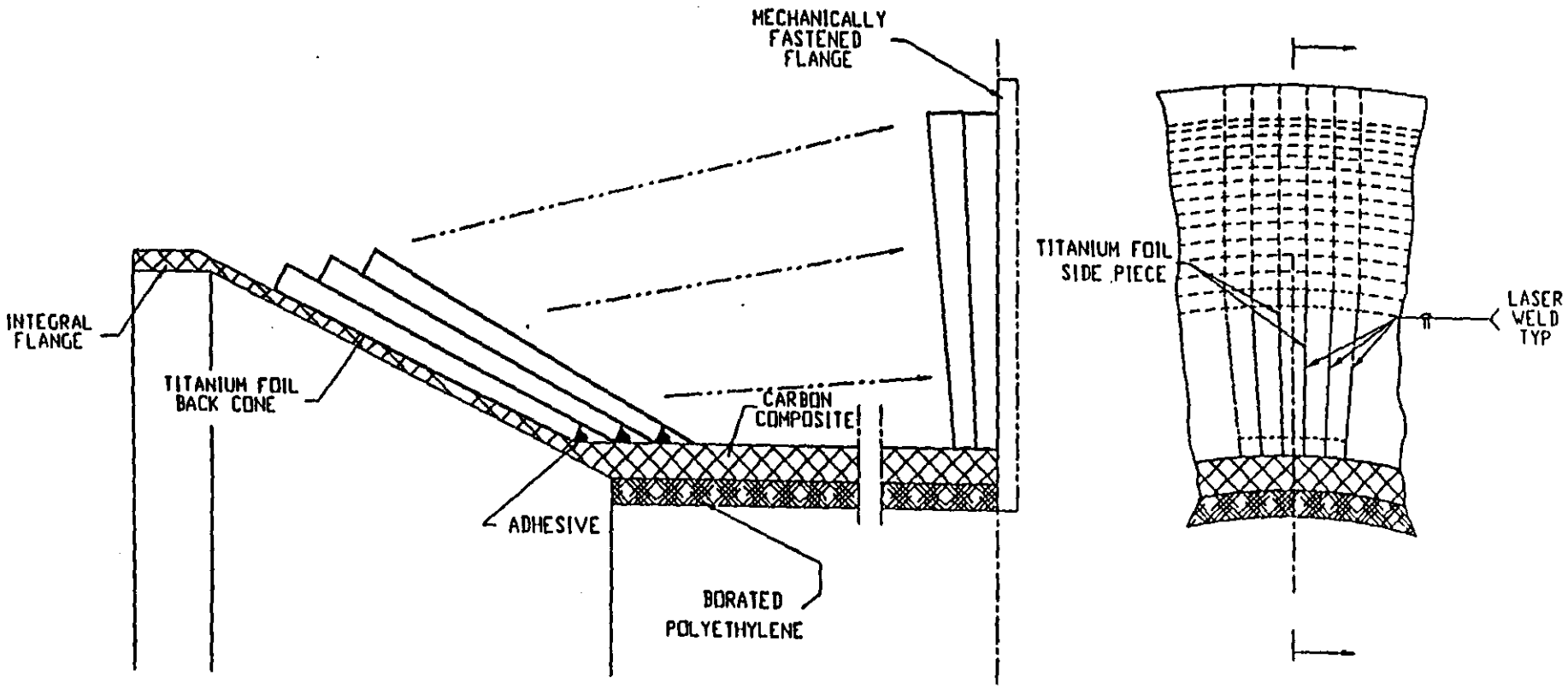
• 90° Reference FACES

• 2 LONG; + ENDS

Barium Fluoride
Preferred Crystal Tolerancing

• MACHINED IN PAIRS

• 100μm TITANIUM alloy FOIL STRUCTURE
LASER (OR ELECTRON BEAM WELDED



CALORIMETER STRUCTURE ASSEMBLY - PART 3

TSINGHUA:
100μm Titanium
Alloy, LASER Welded
Prototype Structure

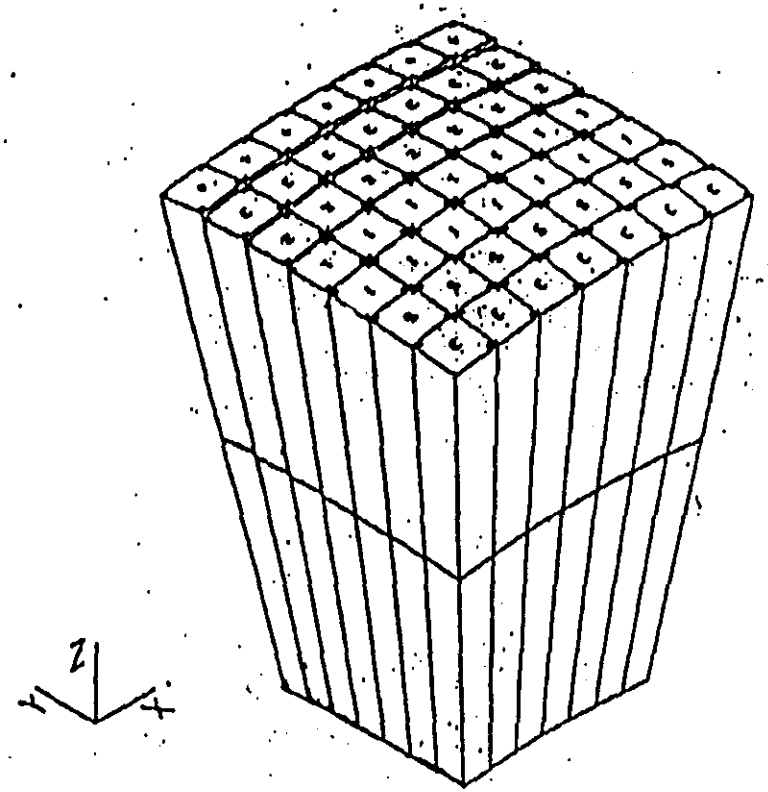
Proposal for welding 7x7 cels supporting structure of GEM Detector Barrium Fluoride EM Calorimeter

Ke-ren Shi, Jia-lie Ren, Yun-ming Zhu
Wu-zhu Chen, Yan-xian Li, Bing-yi Yan

Dept.of Mechanical Engineering
Tsinghua GEM Collaboration
Tsinghua University,Beijing China
Fax: (861)2568116

1. welding 7x7 cells of GEM Detector Supporting structure

1.1 Fig.1 shows the structure of 7x7 cells.



$30K

in China.

3. Cost Estimate for 7x7 cells of GEM Detector Supporting structure

No	item	Labor k$	Material k$	Subtotal k$	Conting. k$	Total k$
1.	Total Costs	4.8	22.05	26.85	3.15	30.0
1.1	Ti sheets (0.1mm,16kg)	0.6	5.7	6.3	0.5	6.8
1.2	Moulds	2.0	7.0	9.0	0.6	9.6
1.3	Laser welding	2.0	9.0	11.0	2.0	13.0
1.4	Testing	0.2	0.35	0.55	0.05	0.6

Date: July 22, 1992

Specification for
• An Instrument Inspecting BaF2 Crystals

Li Dacheng, Wang Dongsheng
Yu Guanzheng, Zhang Yunxiang

Dept. of Precision Instruments
Tsinghua-GEM Collaboration
• Tsinghua University, Beijing China

This instrument has the performance which can inspect dimensions of BaF2 crystals (flatness, perpendicularity, contour, and all dimensions).

• A comparison between the new instrument and that used by Shanghai Institute of Ceramics (SIC):

Items	the new instrument	SIC's instrument
Measuring range	0-250mm and 0-500mm	0-250mm only
Measurement software	all measured objects	No
Resolution	0.3μm	0.5μm
Precision	+-3μm	+-5μm
The number of inductive gauging heads	84 heads	42 heads

BaF_2 RADIATION DAMAGE

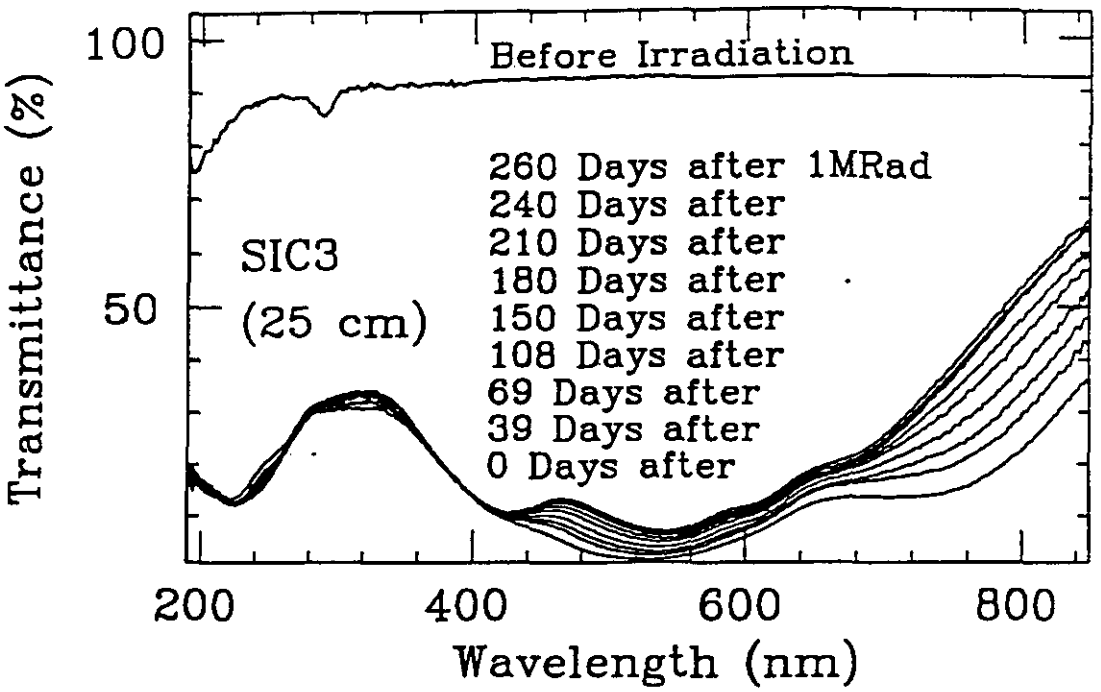
Is The Main R&D Issue

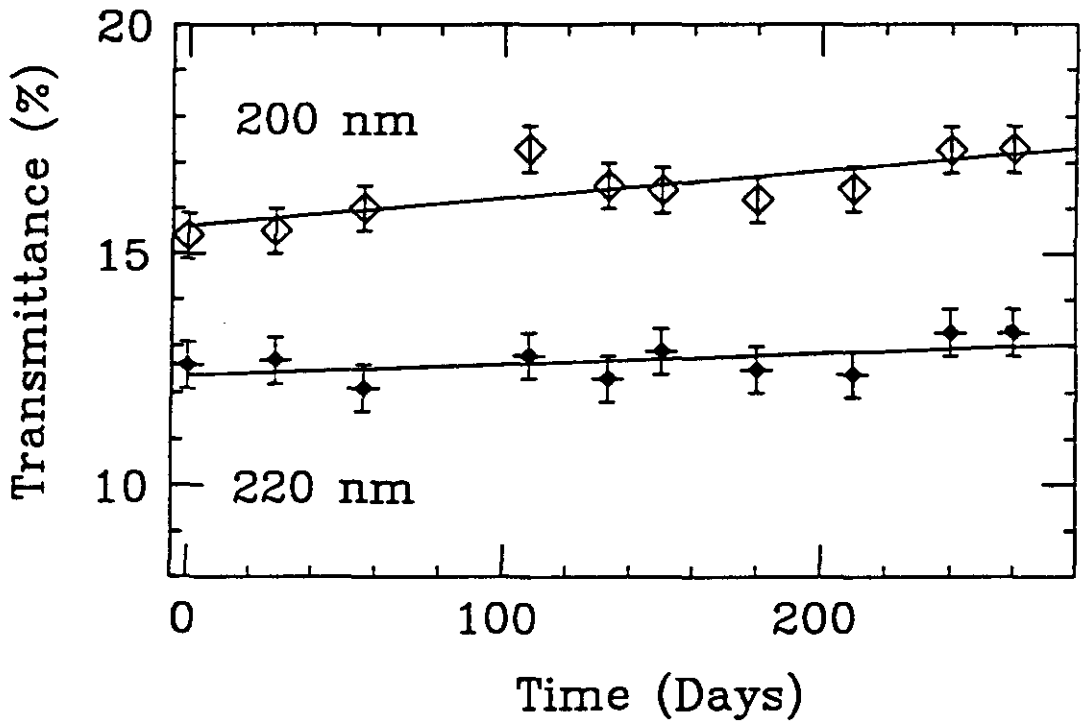
SUMMARY OF FACTS

- Significant Progress On Rad Hardness
- → A Decrease In Light Transmission; No Evidence for Intrinsic Scintillation Loss
- → Radiation Effect (Photons) Is Saturated At $\leq$ 100 kRads: Yield and Transmission
  - Saturated Crystals are Rad Hard ($\geq$ 1 MRad)
  - Needs Confirmation for Hadrons:
    → Tests At BNL
- → No, Or Very Slow Post-Irradiation Annealing at Room Temperature in Darkness
- → Small Effect of MeV Neutrons (Lowell): 7×10^{13} n/cm^2 $\leq$ 1 kRad Co^{60} for all Partice Types
- → Full Recovery With 500° C; UV Light.
- → Evidence for Primary Role of Oxygen Or Hydrogen (OH^-) in the Damage (Tongji, Univ. of West Virginia)
- → Best Crystals Tend To Have Least Impurities: Rare Earths, Oxygen, Carbon, Metals (CEGA; SIC; BGRI)
- → Microstructural Differences in New Crystals; Crystals Must Be Properly Annealed
- Attenuation Length (220 nm) To Be 95 cm
  - Currently $\geq$ 40 cm In Large Crystals (July)
  - Improvement to > 60 cm May Be Achievable By End August

BaF_2 R&D STATUS (July 1992): RADIATION DAMAGE TESTS

- SATURATION (With PHOTONS), FROM ~50 kRads:
  - No Measureable Recovery At 220 nm After 7 Months (Caltech)
  - Possible Slow Recovery Over 7-9 Months (BNL)
- NEUTRON IRRADIATION AT UNIV. LOWELL
  - 7×10^{13} MeV n/cm^2: Little or No Measureable Damage Due To Neutrons
  - → Damage Consistent with Photon Dose Only
- HADRON IRRADIATION AT BNL AGS
  - First Data On Hadron Versus Photon Damage
  - Up To MegaRad Doses: Report By Woody
    ↳ LESS DAMAGE THAN γ's PER UNIT DOSE





Recovery @ R.T. for a 25 cm long BaF_2

Very slow spontaneous recovery

Dec, 1991

• SIC Crystal: Saturation in Transmission and Light Yield Loss
A 25 Cm long BaF_2 Crystal

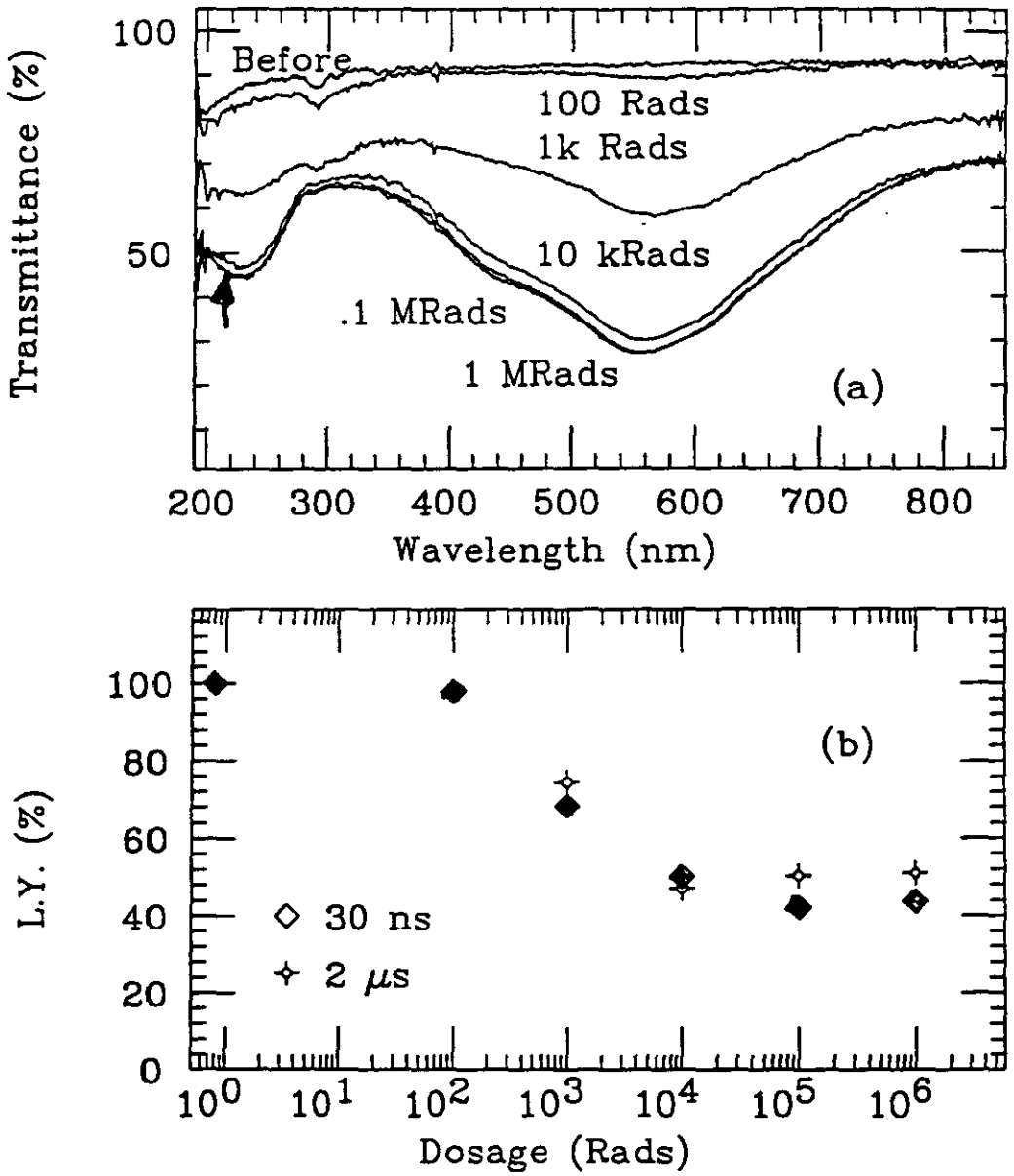


Figure 6: Transmittance (a) and relative light yield (b) measured with a 25 cm long BaF_2 crystal are shown as function of dosage.

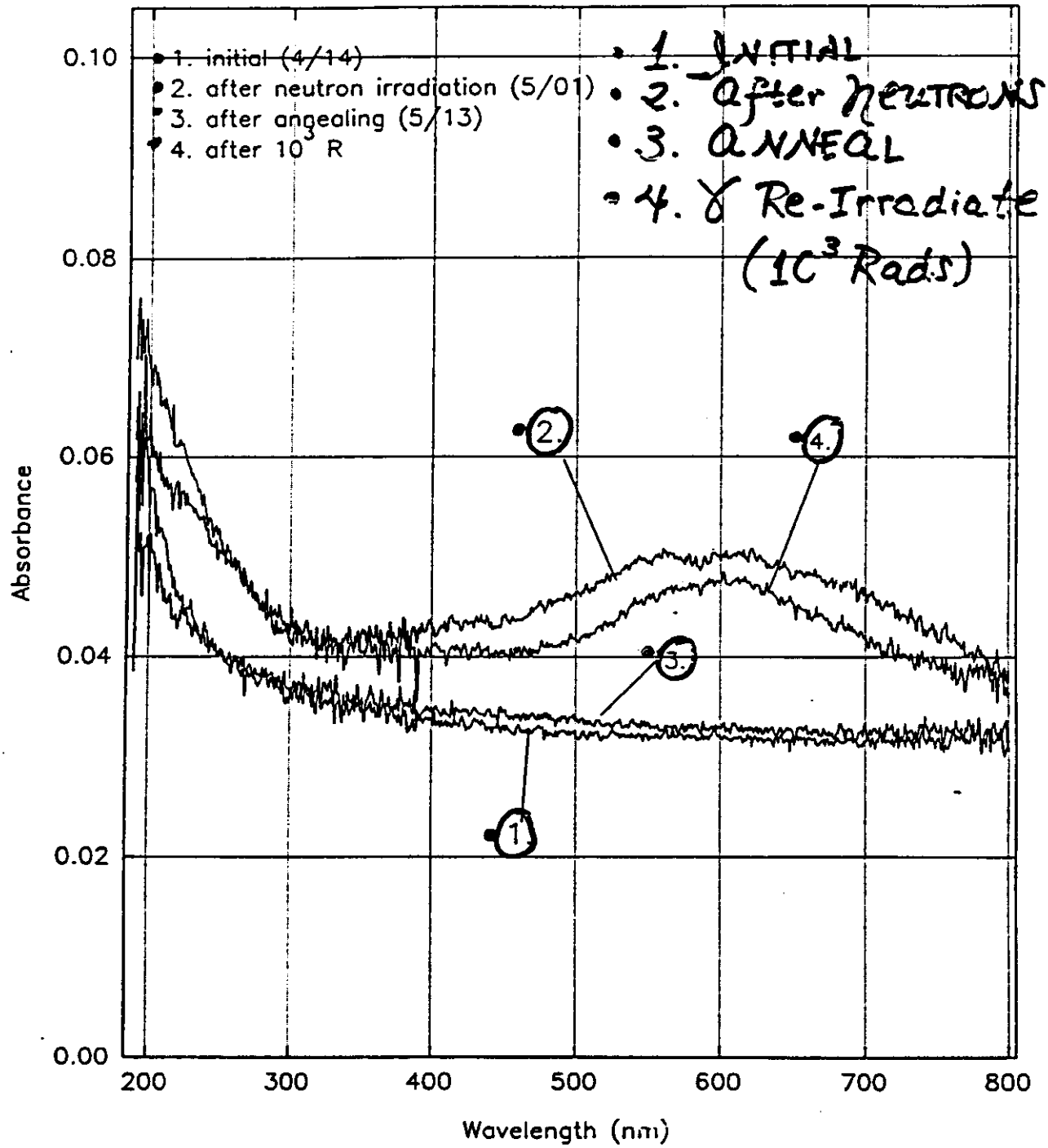
• $\mathcal{L}_{att}$ > 40 cm: Best Achieved.

Fast neutron irradiat

SIC

BaF_2 1" X 1" cylinder # S-9 5/26/92

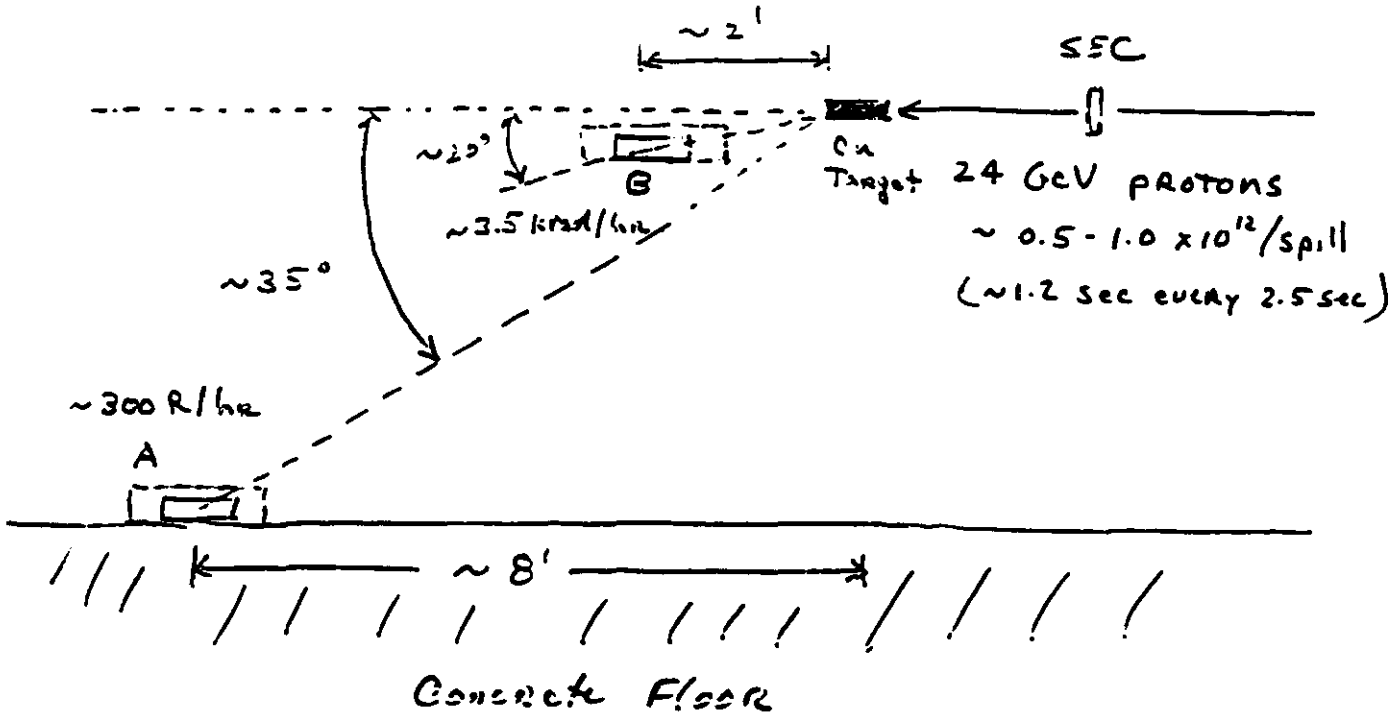
neutron irradiated then annealed and re-irradiated to 10^3 R.



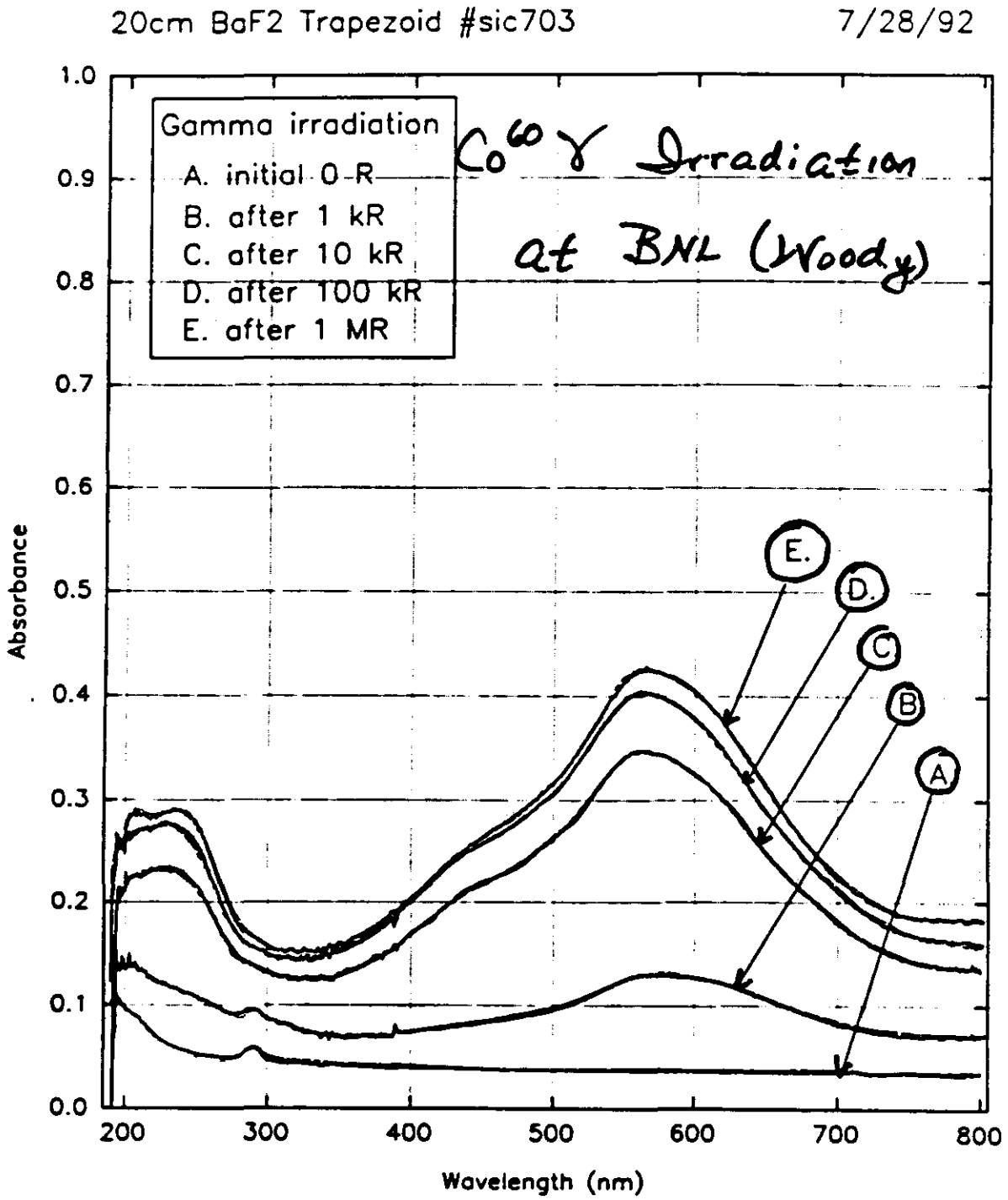
• C. WOODY et al. (BNL):

→ SIC Crystal: (1) [illegible] or no Effect of MeV Neutrons; (2) Annealable after Irradiation.

AGS IRRADIATIONS

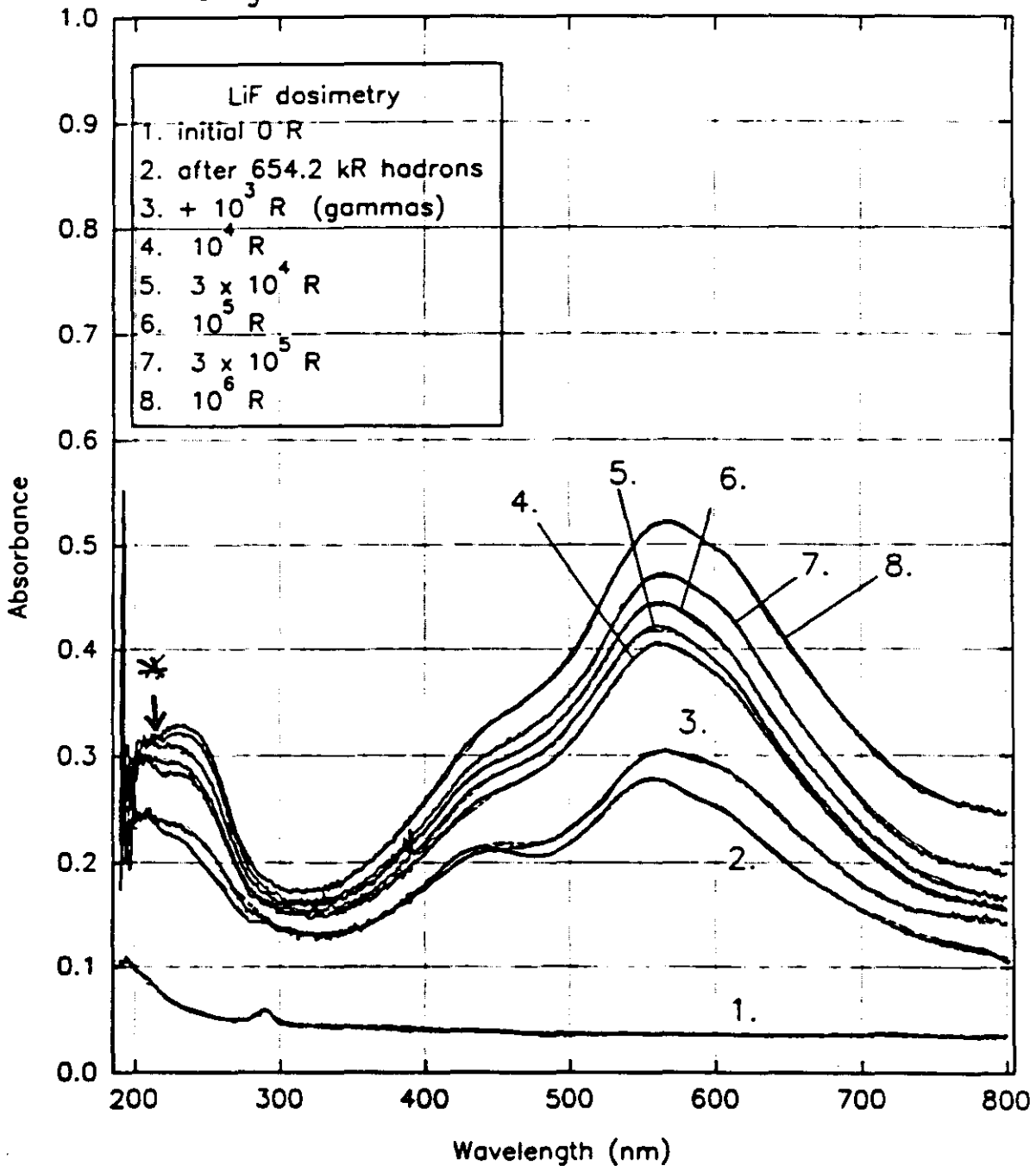


- Irradiations took place between 6/15 - 7/26
- Intermittent beam conditions (Real life!)
- Access required shutdown of entire AGS (all experiments and test beams - VERY UNPOPULAR!)
- Installation and removal of samples required access to high radiation area (typically few R/hr - DANGEROUS!)
- This was NOT a continuous exposure to pure hadrons (mixture of π^+, π^-, p, n and γ's - mainly from π^0's)
- Average energies ~ few GeV (much lower than SSC)
- Dose rate measured in LiF dosimeters for D ≤ 100 krad
- For D > 100 krad, SEC was used to extrapolate LiF dose
- Dose (MeV/kg) in BaF_2 ~ 4 x dose in LiF


20cm BaF2 Trapezoid #sic703
7/28/92
Gamma irradiation
A. initial 0 R
B. after 1 kR
C. after 10 kR
D. after 100 kR
E. after 1 MR
Co60 γ Irradiation
at BNL (Woody)
E.
D.
C
B
A
Absorbance
Wavelength (nm)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
200
300
400
500
600
700
800

20cm BaF2 Trapezoid #sic703 7/31/92

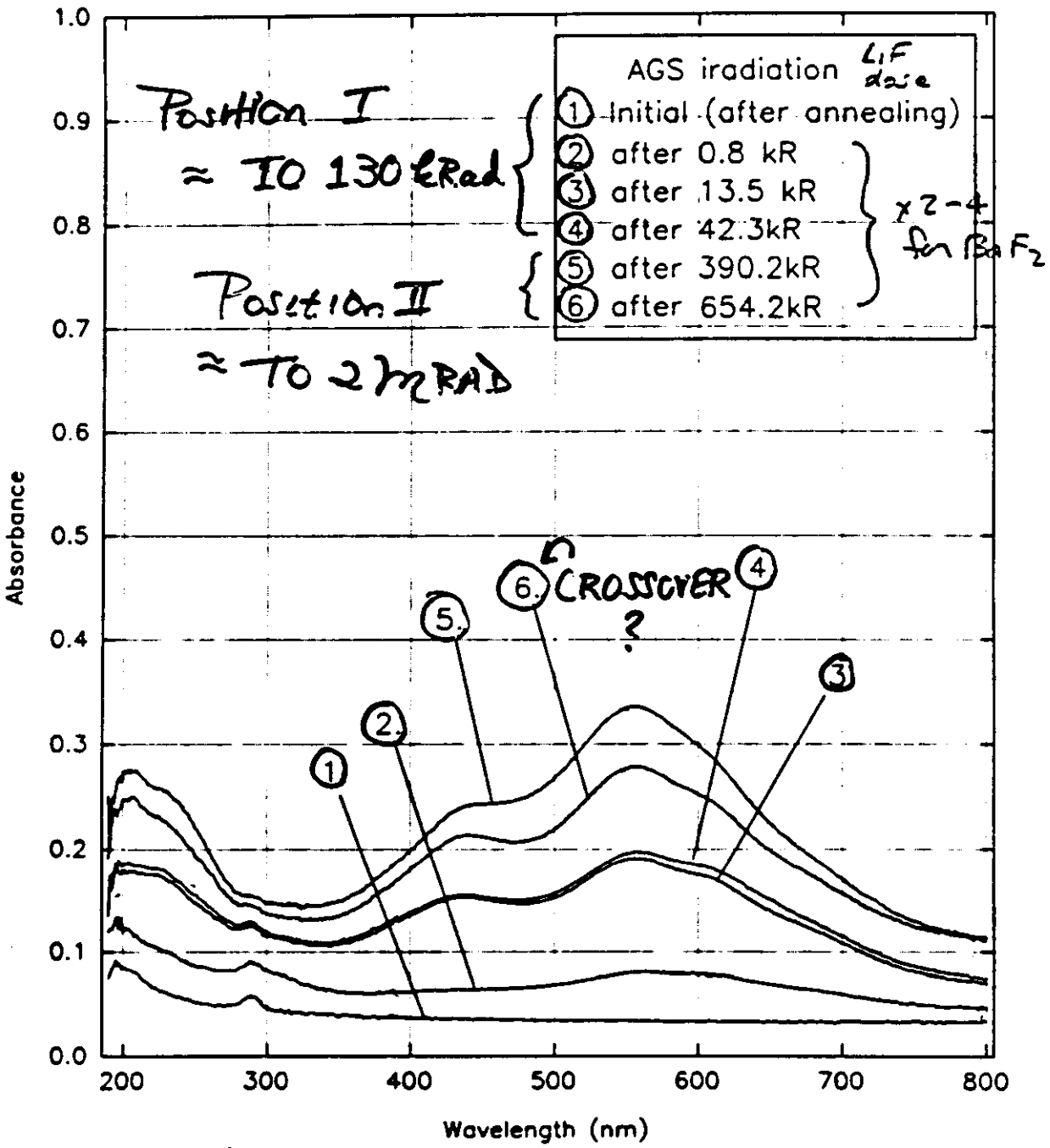
Irradiated with 654.2 kR of hadrons then, without annealing, 1 MR of gammas .



* After ≈ 2MRad Hadrons + 1 MRad γ's : "Resaturation"

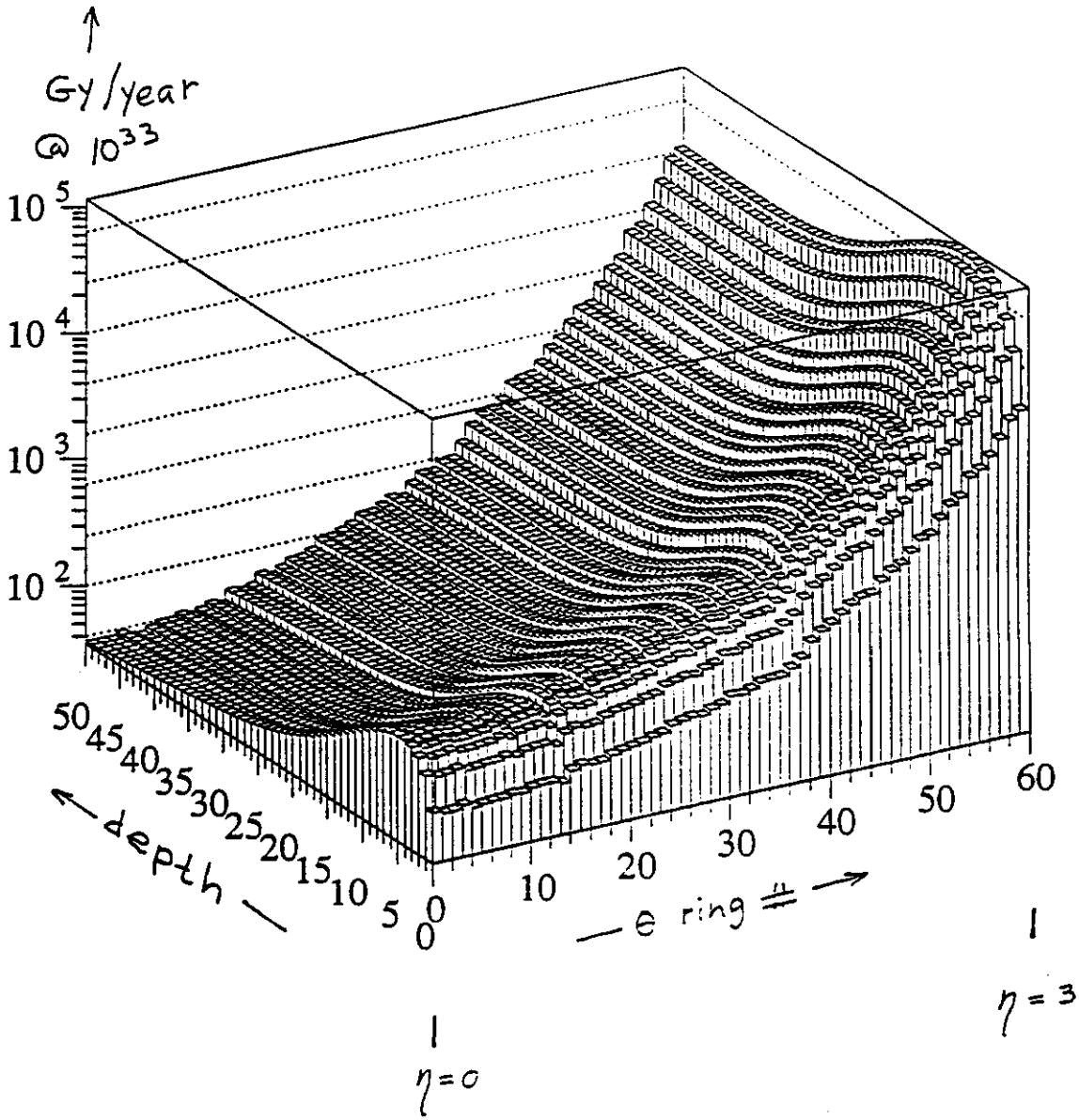
• Compare to SSC Doses.

20cm BaF2 Trapezoid #sic703 7/28/92



* Less Absorbance Than γ's Per Unit Dose.

? ⑥: Self-annealing



Doses in GEM BaF_2

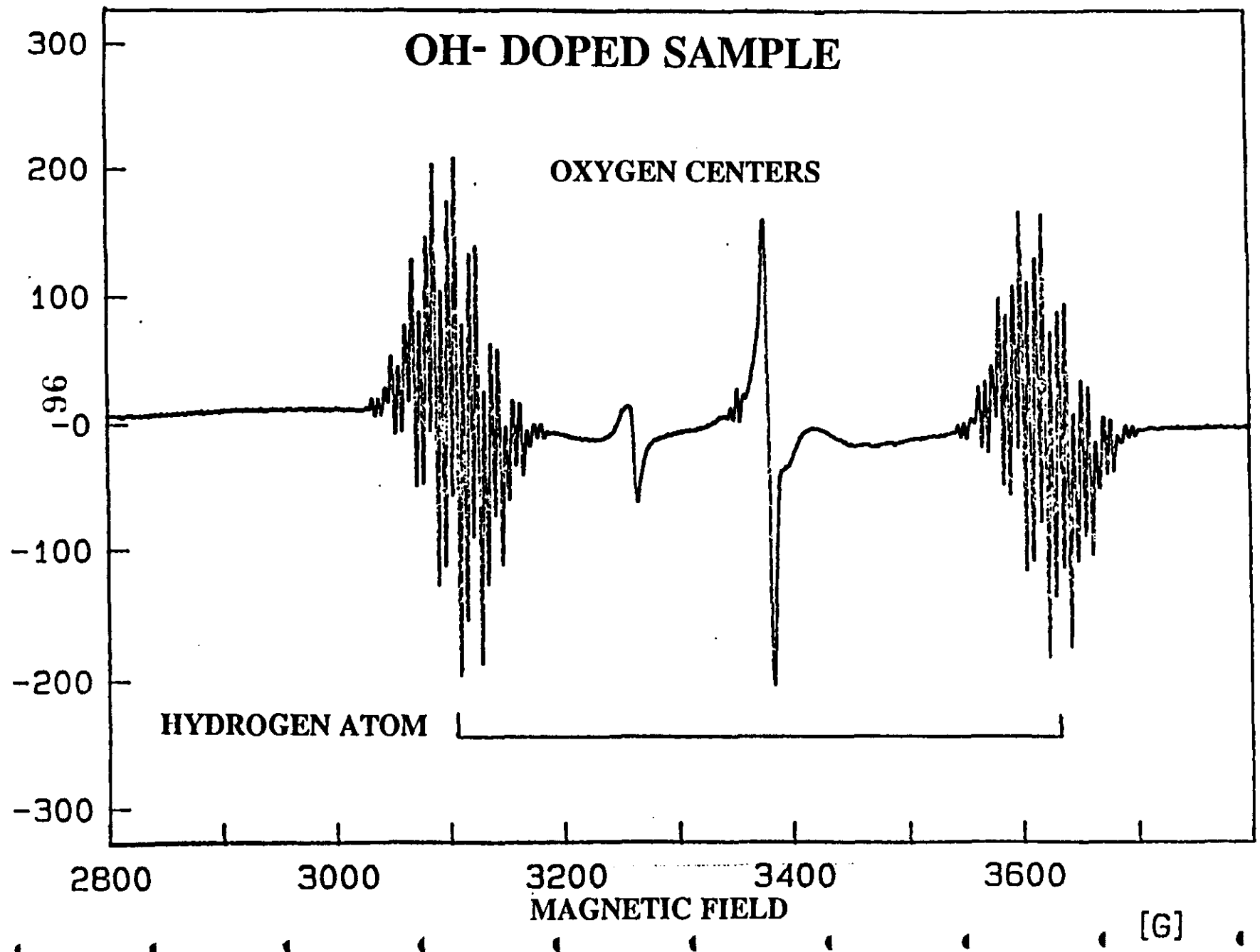
V. Morgunov@SSCL

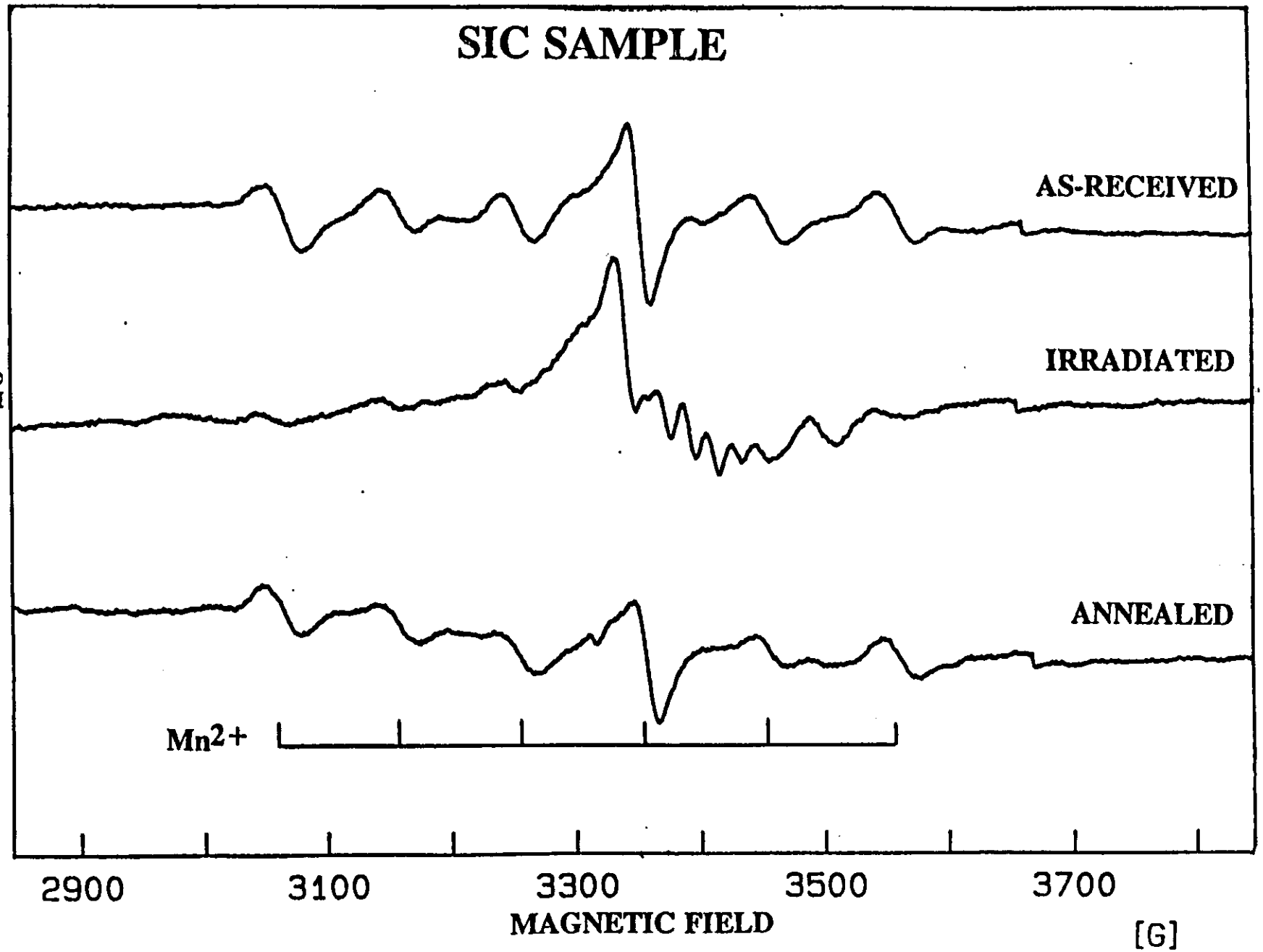
BaF_2 R&D STATUS (7/92): PREIRRADIATION OPTION: INDUSTRIAL FACILITES AVAILABLE

- ISOMEDIX, Inc. (El Paso)
  - 1.5 MCi Co^{60} Source Array: 12′ × 8′ Vertical
  - Mount Crystals in 10" × 10" × 21" Cartons Wrapped in Large Bubble Plastic
  - Four Passes (Two Per Side) on Conveyor Belt
  - Process a Truckload At Once
  - COST Estimate: \$5 - \$7 Per "Crystal" → ≈ \$100K
- STERIGENICS INTERNATIONAL (Fort Worth)
  - 2.2 MCi Co^{60} Source Array: 10′ × 8′ In Two Vertical Walls
  - Conveyor Belt: Carriers ('Totes') 60" × 24" × 40", Pass on One Side, Between Walls, Other Side
  - Mount 39 Crystals Per Tote (1/2 Crystal Spacing); 5 Hours for 1 MRad
  - Total 410 Totes, at \$60 Per Tote: TOTAL COST = \$25K.

BaF_2 R&D STATUS (JULY 1992)
SMALL CRYSTAL PRODUCTION; DAMAGE MECHANISM

- KEY ROLE of O and/or H: Confirming Evidence From Tongji and West Va. Univ. (WVU):
  - OH^- Doped Crystal Studies: High Temperature Annealed in Air
  - UV and Infrared Absorption Bands Measured Match Tongji Computations
  - Electron Paramagnetic Resonance (EPR) Spectrum at WVU:
    - * Interstitial H and Substitutional O^- Identified After Irradiation
    - * Correlated With UV Absorption Bands
- DAMAGE MECHANISM: ROLE OF TRACE ELEMENTS in Color Center Formation (WVU)
  - Mn^{2+} Valence Change Observed in EPR Spectrum
- OXYGEN, FAST COOLING, and DAMAGE STUDY at SIC
  - Improper Annealing (Fast Cool Down) Leads to Decreased Rad Hardness
  - Crystals With More O_2 Show Larger Changes Seen Under the Electron Microscope


OH- DOPED SAMPLE
OXYGEN CENTERS
HYDROGEN ATOM
300
200
100
0
-100
-200
-300
2800
3000
3200
3400
3600
MAGNETIC FIELD
[G]


SIC SAMPLE
AS-RECEIVED
IRRADIATED
ANNEALED
Mn2+
2900
3100
3300
3500
3700
MAGNETIC FIELD
[G]

POSSIBLE ORIGINS OF THE ULTRAVIOLET ABSORPTION IN BaF_2 CRYSTALS AFTER IRRADIATION AT ROOM TEMPERATURE

A. INTRINSIC DEFECTS (Fluorine Vacancies, Interstitial Fluorine Ions, Etc.)

Highly Unlikely!

→ No Intrinsic Defects are Known in BaF_2 That Have An Absorption Band Near 200 nm.

B. HYDROGEN AND OXYGEN IMPURITIES

Highly Likely!
Easily Incorporated During Growth.
Easily Affected By Radiation.

C. TRANSITION-METAL AND RARE-EARTH IMPURITIES

Highly Likely!
Present in Starting Material For Crystal Growth.
Easily Change Valence State During Irradiation.

CONCLUSIONS

- BaF_2 is an intrinsically radiation-hard material, especially in the ultraviolet.

- Radiation-induced ultraviolet absorption bands are due to small concentrations of hydrogen/oxygen and transition-metal ions (Mn^{2+}).

Two ways to minimize radiation damage in BaF_2:

1. Continue to improve crystal growth procedures (progress is being made in this direction).

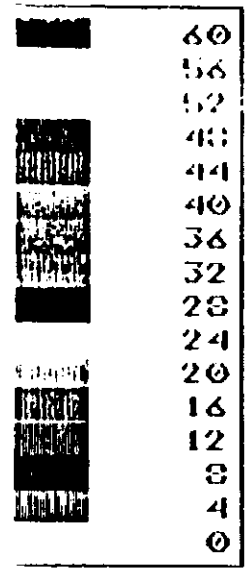
→ 2. Develop a post-growth procedure to remove unwanted impurities. One possibility is electrodiffusion, where an external electric field applied during irradiation drives impurities out of the crystal.

BaF_2 R&D STATUS (JULY 1992)

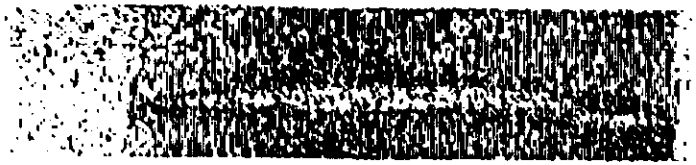
MATERIALS PROPERTIES and RADIATION DAMAGE

TRACE ELEMENT and MICROSTRUCTURAL ANALYSIS AT CHARLES EVANS and ASSOCIATES

- Impurities Concentrated in Precipitates DOMINANT
- Depth Profiling and Field Imaging Inclusions (SIMS)
- New Crystals (With Improved Rad Hardness) Show Different Properties:
  - Much Lower Rare Earths (GDMS); Much Lower Carbon; Lower Oxygen (Gas Fusion)
  - Large Regions With NO Inclusions: (To Be Correlated With Growth Parameters)
  - Fewer Total Inclusions
  - Inclusions Are Clustered Together
  - "Swirl Patterns" As Seen in Silicon; Connected By "Pipes" Along Crystal Planes
- Work In Progress (July - August):
  - Correlate Radiation-Induced Microscopic Coloring at Inclusion Sites With Macroscopic Absorption
  - Analyze New LLNL, OPTOVAC, SIC and BGRI Crystals
  - Cross Check CE&A Trace Analyses at NRL (DRT: 10 - 100 ppb Sensitivity)



12BOXS
10 Jul 92
12:30:01
18.0 mass
7.0 sec

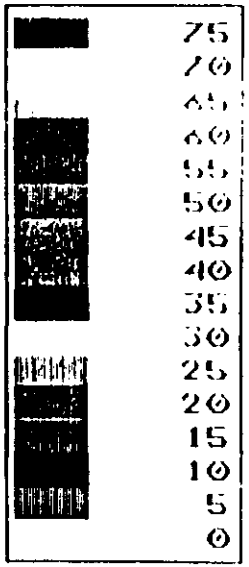


18 OXYGEN

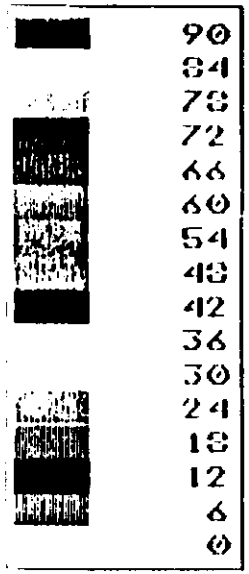
37 CHLORINE

3D Reconstruction of TRACES IN Inclusions

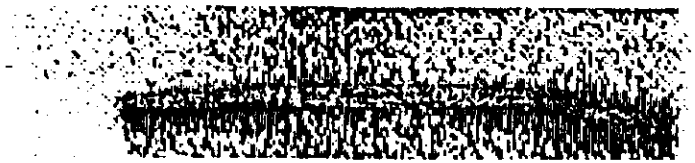
SAMPLE S52 #23



12BCLXS
10 Jul 92
13:52:36
37.0 mass
7.0 sec

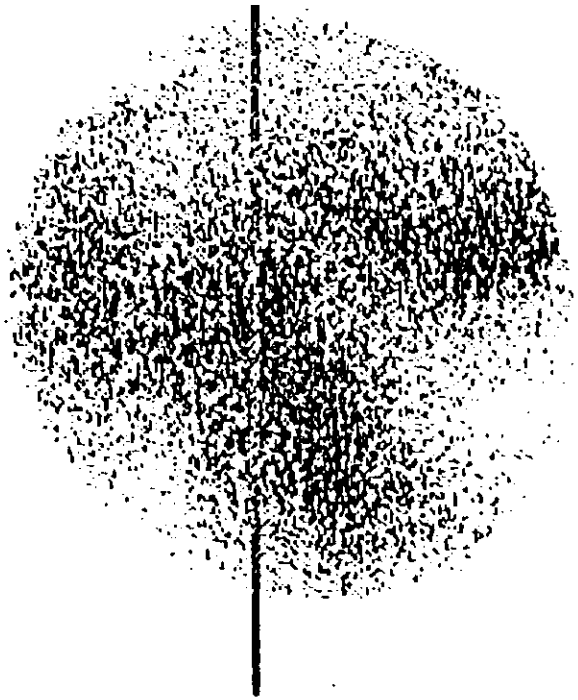


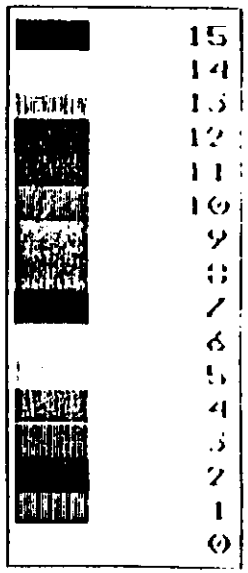
12BSXS
10 Jul 92
12:26:28
34.0 mass



34 SULFUR

NEW MC Crystal Slice #23





DP45445 M
25 Jun 92
X:100
Y:243

Theory D'Jour

Old Crystals

Rare Earth Impurities
High Color Center Generation Rate

Large, Random Inclusions
High Resistivity
Low Color Center Destruction Rate

New S52 Crystal

Low Rare Earth Concentration
Low Color Center Generation Rate

Small, Interconnected Inclusions
Lower Resistivity
Phosphoresence Self Heal?
Higher Color Center Destruction Rate

Cobalt Irradiation
S52 and T Series BaF2

Samples Irradiated at LLNL

115 Minutes (2.3M Rad)

No Color change for S52
Blue Color for T (Prototype)

SEM Analysis

Both Crystals – R.random Inclusions

Color Photocopy of Crystals

Returns T Series to Clear

Incandesent Light Bulb

60 Watts, 12 inch exposure distance

* 0 Minutes Light Blue
* 20 Minutes Light Pink
* 60 Minutes Clear

Future Work

GDMS – T Series (FNAL)

SIMS – Imaging of Sr & H

SEM – Quantify Charging

RBS – Lateral Crystal Quality of T and S52

Establish Photon Energy to Bleach Color Centers

Investigate Self Bleaching

Low energy Phosphor Coating?

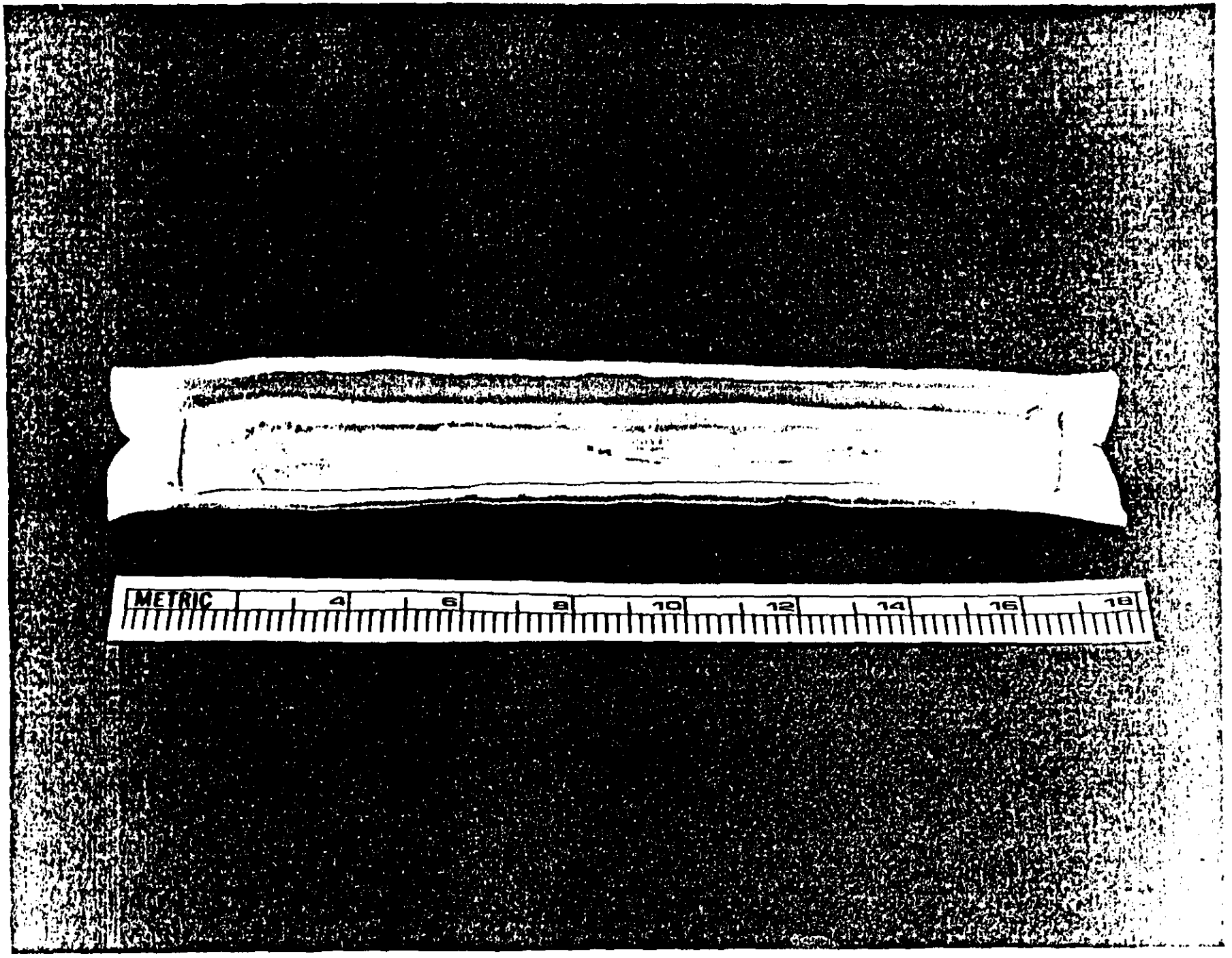
Characterize New Material

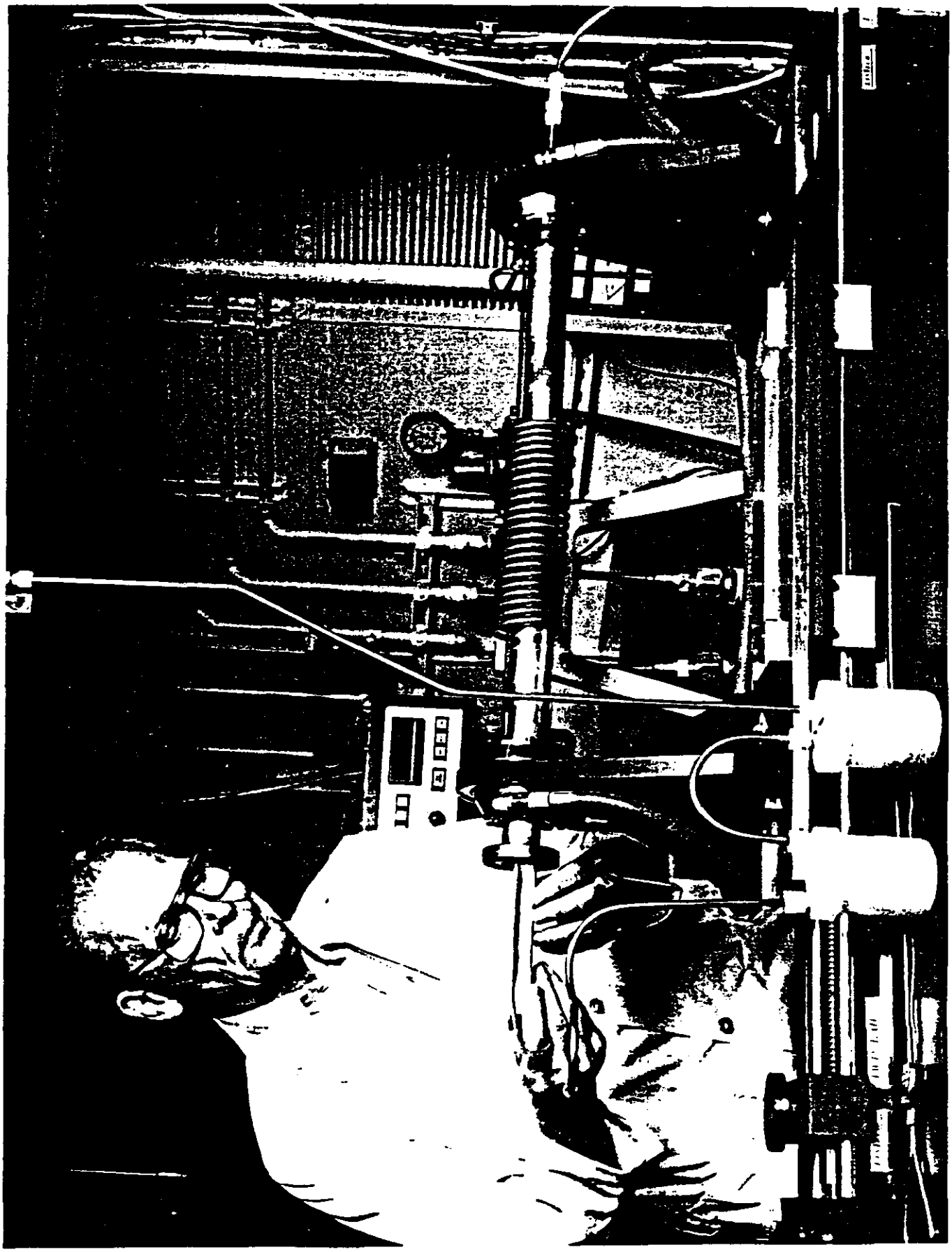
BaF_2 R&D STATUS (July 1992): CRYSTAL PRODUCTION (SIC, BGRI)

- NEWER CRYSTALS
  - T(220 nm) in 26 cm Crystal (SIC): 48% After 1 MRad $\mathcal{L}_{att} \approx 40$ cm
  - 350 mm Crystal (BGRI): Heating System With High Gradient At Solid/Liquid Interface.
  - SIC: Several Improved Crystals From One of Four Factories (Hainan); '703' Scavenger
    - ⇒ Possible Correlation With Cr, Mg Traces
    - ⇒ Tests Needed at CE&A (GDMS, SIMS) and NRL (DRT) in August
- IMPROVED RAD HARD CRYSTALS in August:
  - Chemical Pre-Treatment (BGRI): Remove $Ba(OH)_2$
  - Dry Raw Materials With High Temperature Noble Gas Flow
  - High Vacuum Pre-Melting Furnace: Improved Residual OH^- Extraction
  - Growth In Higher Vacuum: Cold Trap
  - Improved Heating System: Higher Gradient At Solid/Liquid Interface
  - Optimize Growth and Anneal Cycle Parameters:
  - Continue To Study Impurity Effect, Damage Mechanism: Spectroscopy, EPR, e-Diffraction, EELS

BaF_2 R&D STATUS (JULY 1992)
SMALL PURE CRYSTAL PRODUCTION

- SMALL ULTRA-PURE CRYSTAL GROWTH at LLNL
  - Pretreatments With Specific Reactive Gases (Not Just HF)
  - Noble Metal Versus Coated Carbon Crucibles
  - Zone Refining to Increase Crystal Purity
  - First Pure Crystals: Target Date mid-August
- SMALL ULTRA-PURE CRYSTAL GROWTH at OPTOVAC
  - RGA ⇒ Hydrolysis (Outgassing): Use Reactive Gas Scavenger
  - First Growth Runs Done To Fix Oven Cycle
  - Optipur Vs. Sublimed; Special Purity BaF_2 : CE&A GDMS Analysis
  - VUV Bandedge Study
  - → Growth Run With 3 Raw Materials (3 Ingots)
  - → Treated Carbon Crucibles Standard. Ta, Mo and W Pure Metal Crucible Trials in July - August
  - → First Pure Crystals: Goal Mid-August


METRIC
4
6
8
10
12
14
16
18

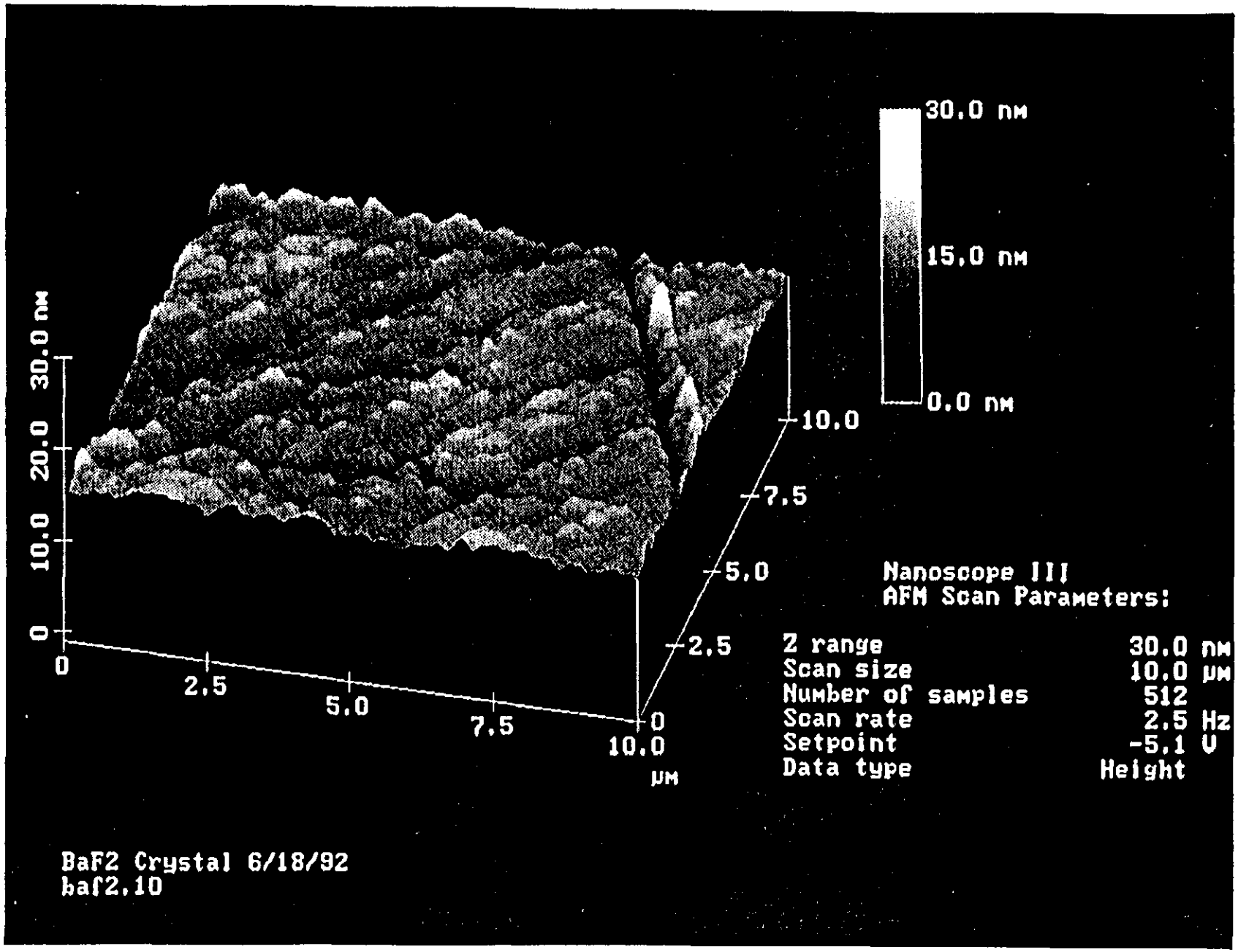


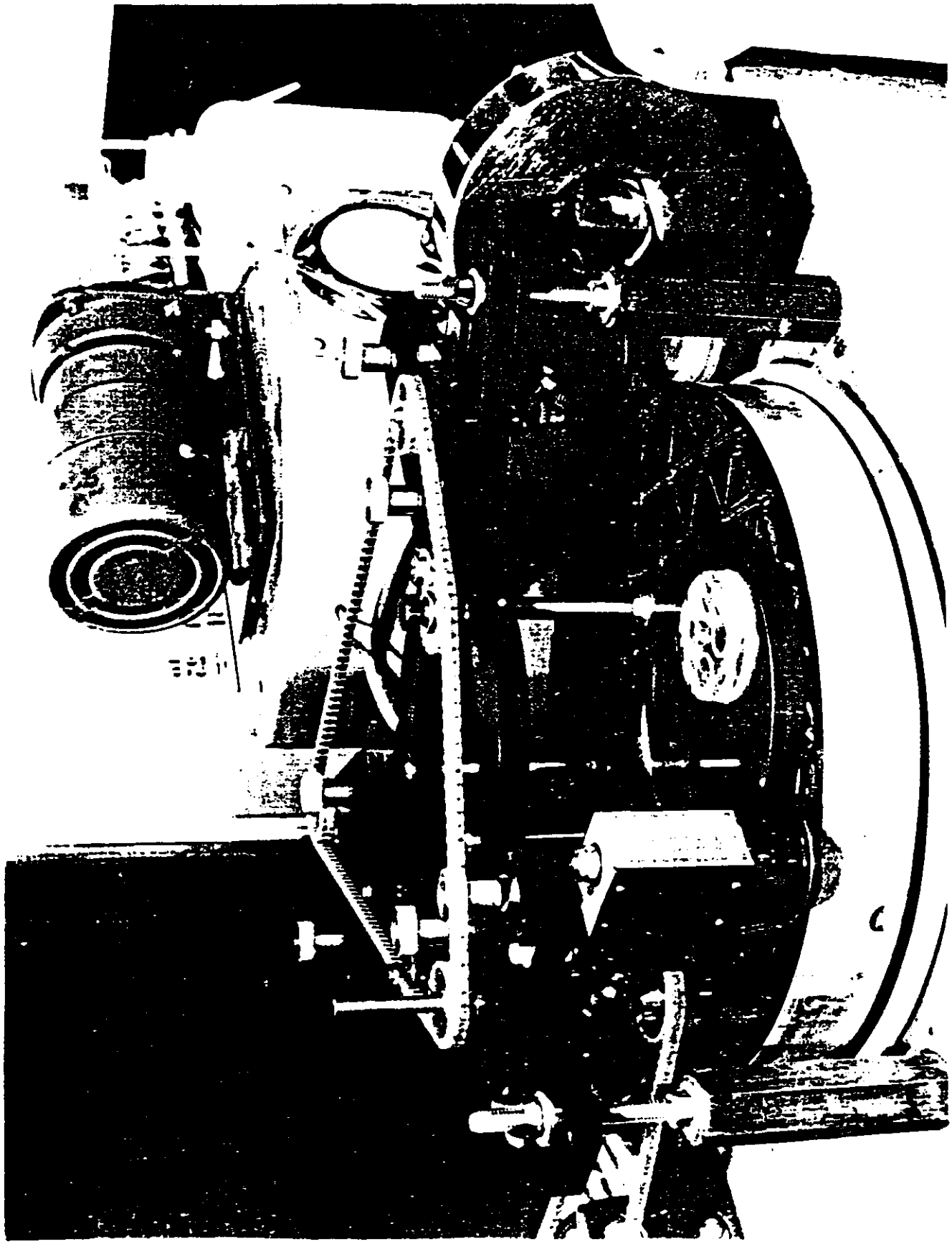
BaF_2 R&D STATUS (JULY 1992)

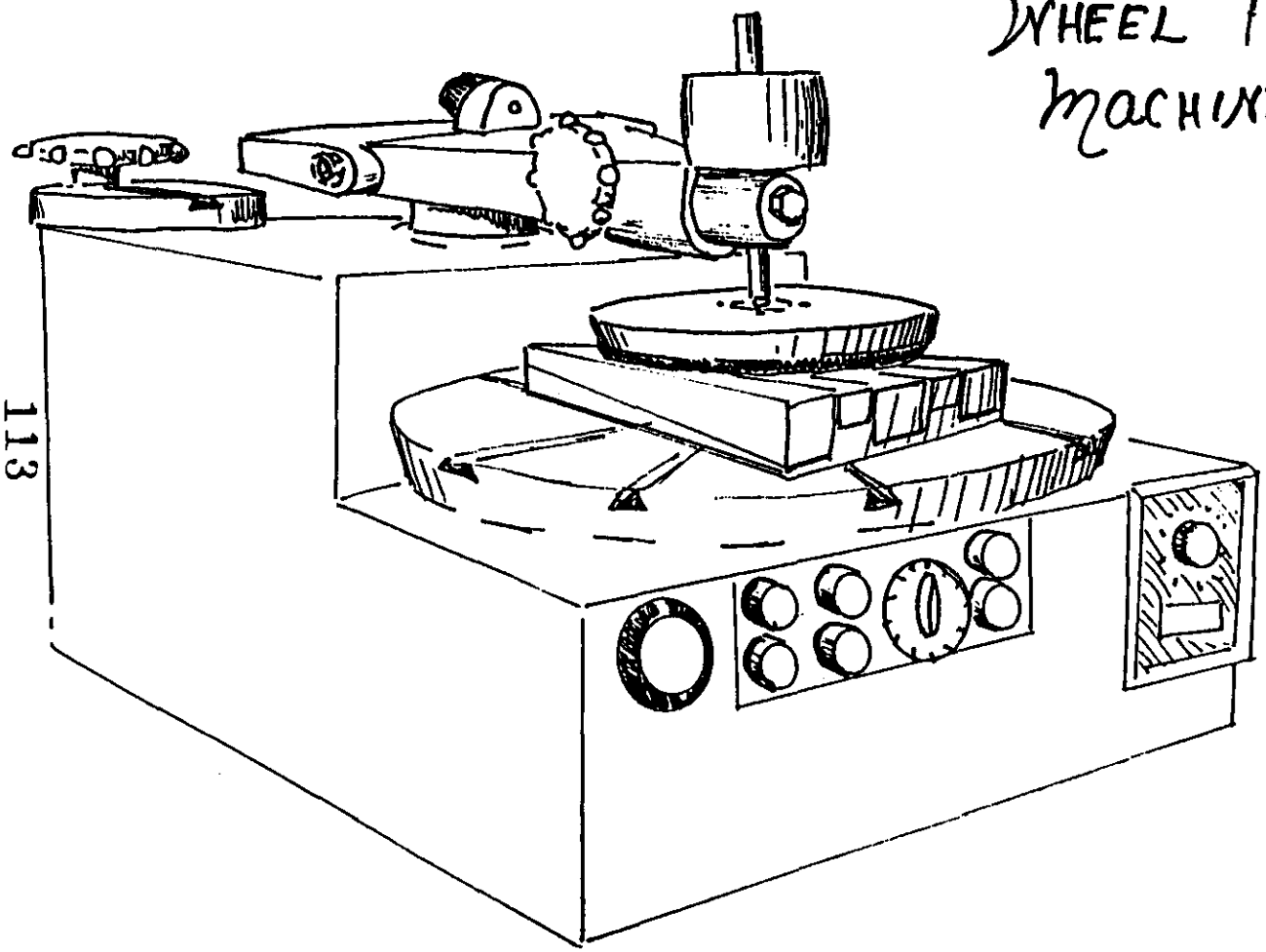
MECHANICAL PROCESSING DEVELOPMENT By LLNL, ORNL

GOAL: Delivery of Finished, Coated Crystal Pairs From China at $ 2.5/cc

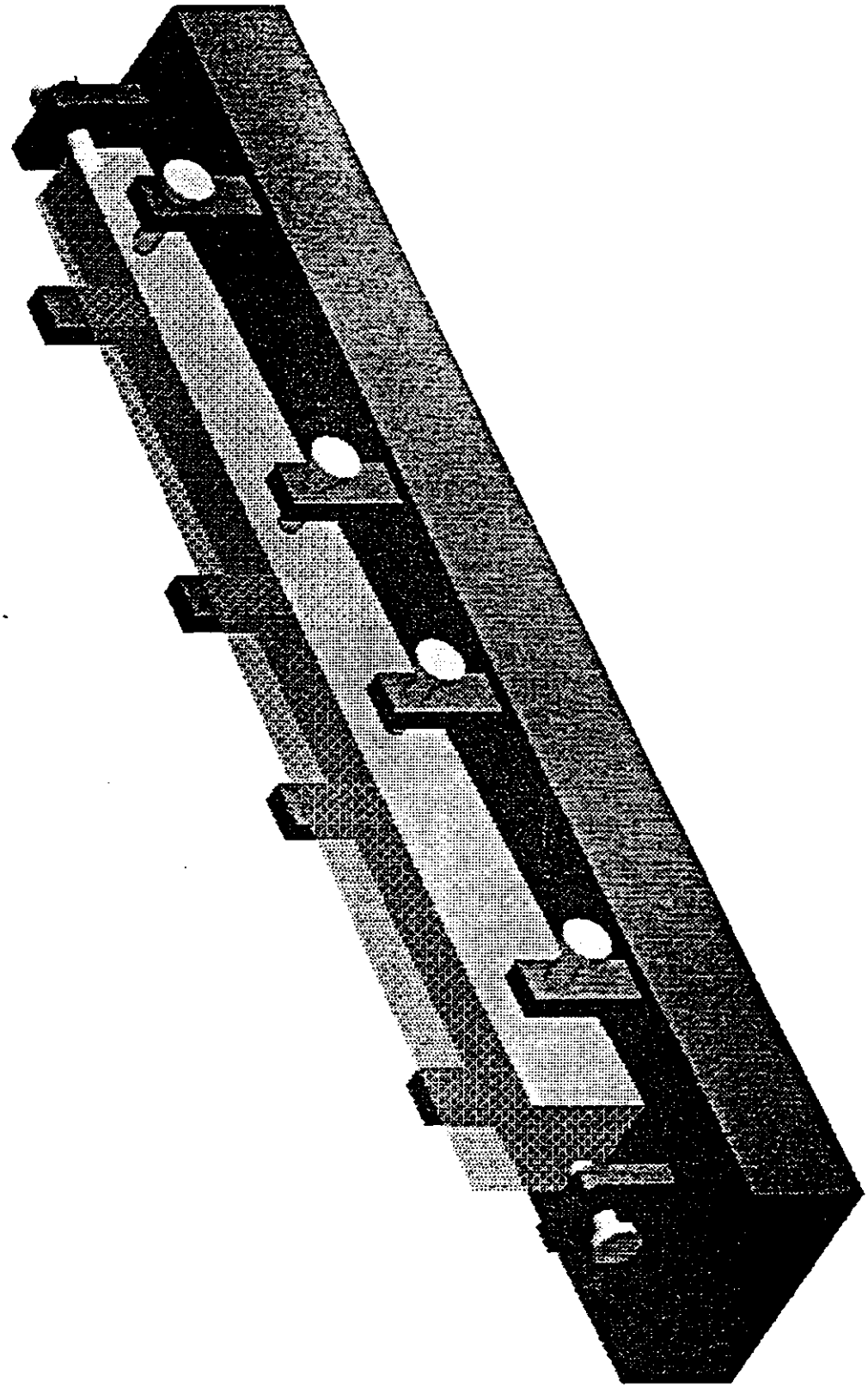
- NEW CRYSTAL DIMENSIONS (ORNL, LLNL)
  - Perpendicular Side and End Reference Faces. • MORE EFFICIENT PRODUCTION, INSPECTION
- SURFACE PREPARATION: MACHINE DESIGN, TOOLING (LLNL):
  - Tests of Ion Beam Milling, Diamond Polishing, Diamond Turning Completed
  - Diamond-Impregnated Pitch Polish Chosen:
    - Roughness 10-20 A° RMS
    - → No Amorphous Surface Layer; Verified at CE&A By RBS
    - Flatness "One-Tenth Wave"
    - Manufacture: Jigs, Process, Machine Designed
    - → Technology Transfer to Zhongnan, BGRI: China Trips in July, August
- UV COATING PROCESS DEVELOPMENT (LLNL) COMPLETED By AUGUST
  - Coating: 90% Reflectance At 220 nm
  - LTRANS Simulation: Compute, Test Graded Coatings (LLNL, Caltech)
  - → Tech Transfer: Zhongnan Expertise, BGRI 4m Tank

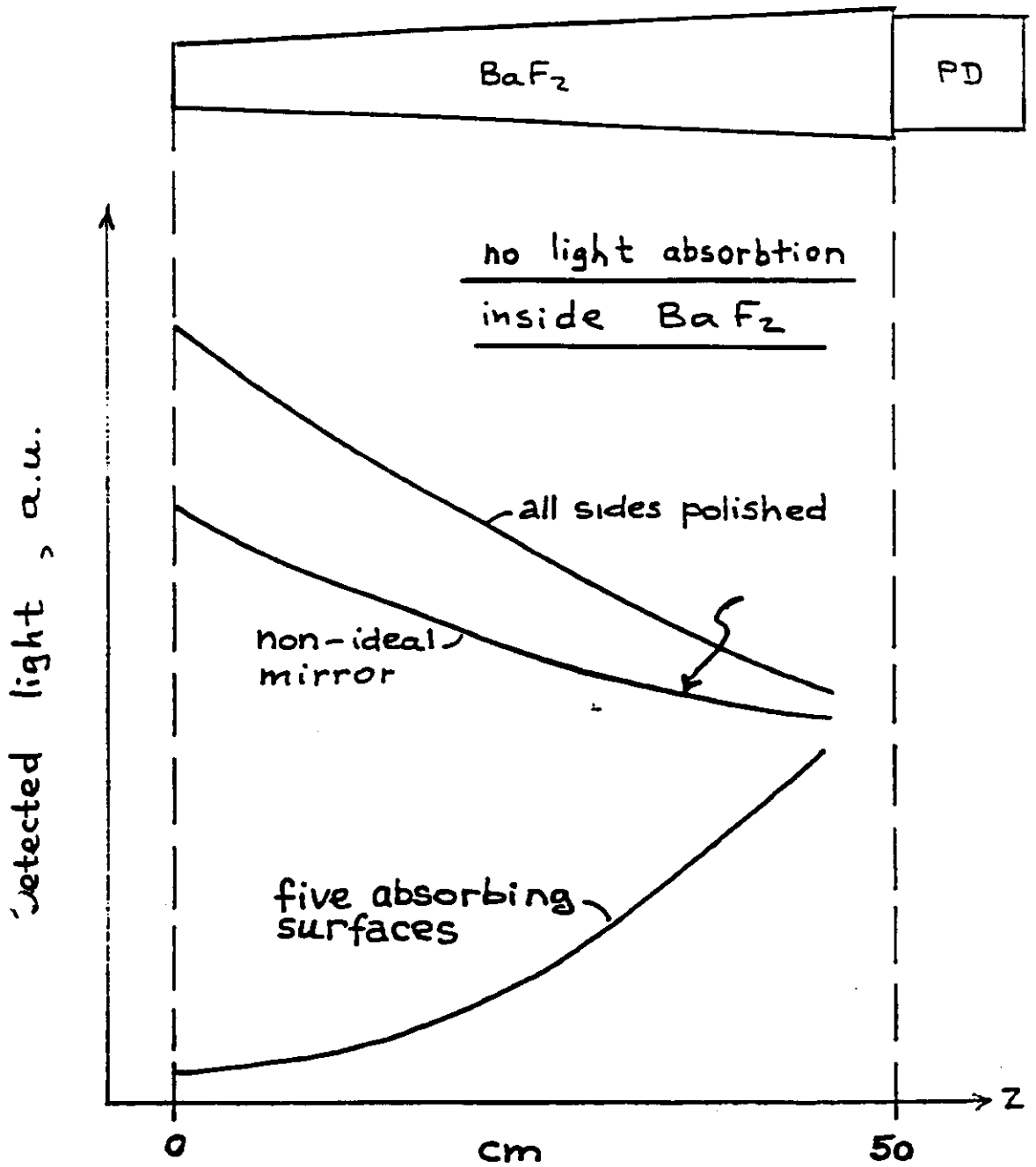

30.0 nm
15.0 nm
0.0 nm
30.0 nm
20.0
10.0
0
0
2.5
5.0
7.5
10.0
µm
0
2.5
5.0
7.5
10.0
Nanoscope III
AFM Scan Parameters:
Z range 30.0 nm
Scan size 10.0 µm
Number of samples 512
Scan rate 2.5 Hz
Setpoint -5.1 V
Data type Height
BaF2 Crystal 6/18/92
baf2.10



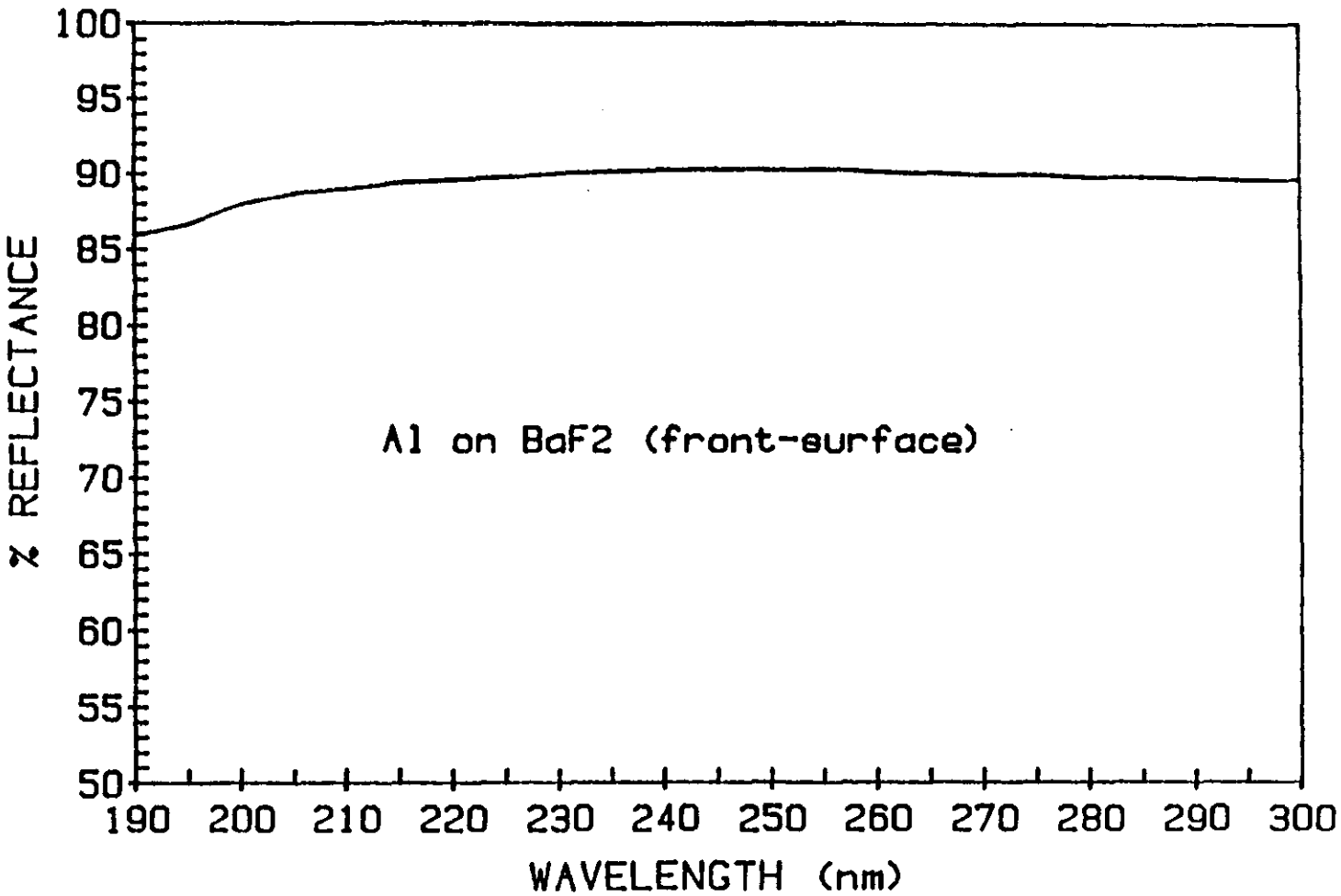


DIAMOND-PITCH WHEEL POLISHING MACHINE





Qualitive effects in BaF_2 coating


100
95
90
85
80
75
70
65
60
55
50
% REFLECTANCE
Al on BaF2 (front-surface)
190
200
210
220
230
240
250
260
270
280
290
300
WAVELENGTH (nm)

SIMULATIONS AND LAB TESTS:

Demonstrate High Resolution

Maintainable In Situ

Max. Constant Term 0.6%

EFFECTS TO BE INCLUDED

- Residual Non-Uniformity (As Installed)
- Non-Uniformity Due to Radiation: Non-Saturation Or Annealing In Situ
- Accuracy of Intercalibration (From Calibration Studies)
- Short Term Instabilities of Readout System.
- Linearity, Linearity Calibration and Dynamic Range of Readout System.

Monte Carlo Studies for BaF_2 at ORNL

Progress Report

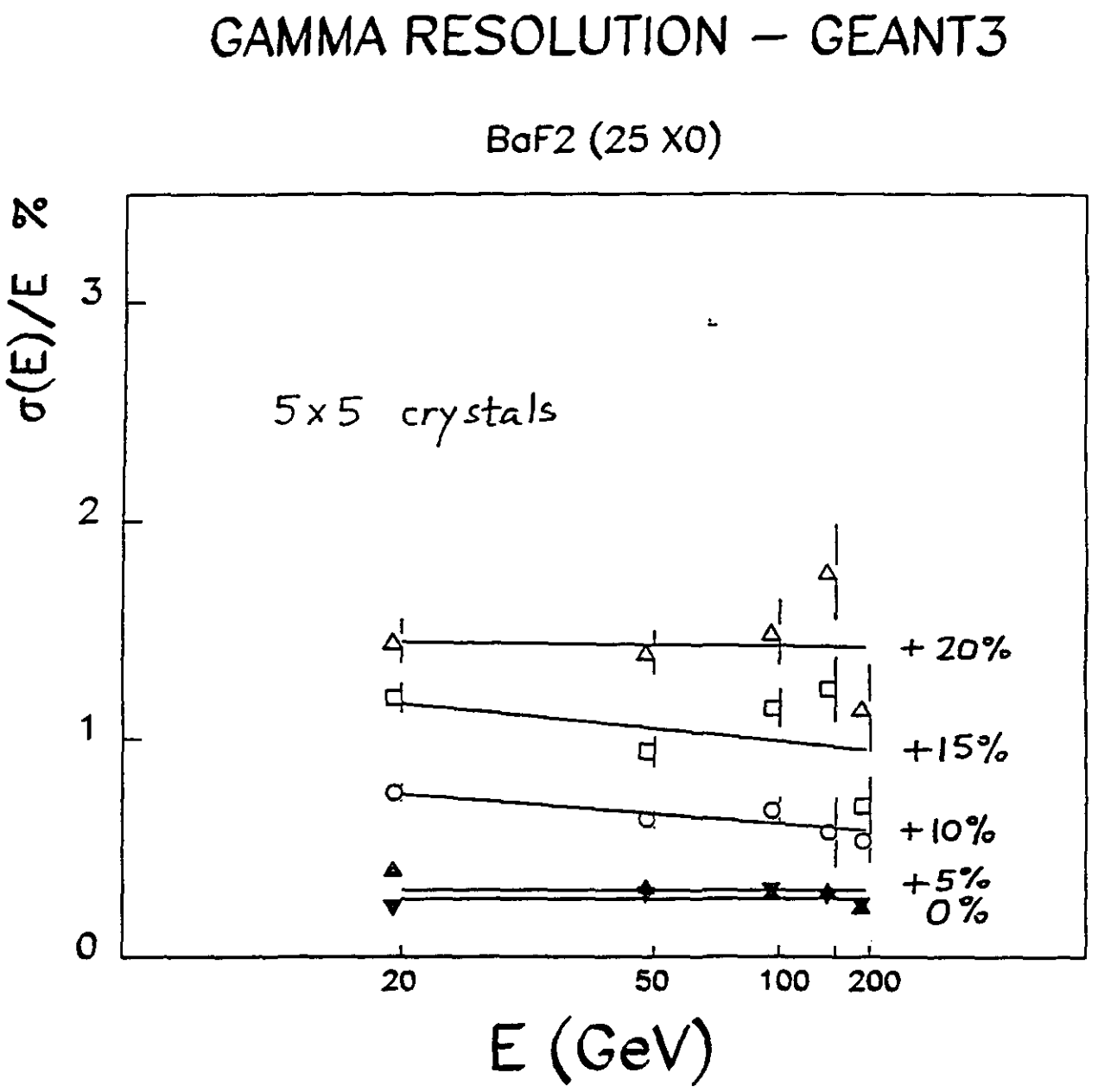
(Status July 31, 1992)

CONTENTS

- #1 UNIFORMITY OF THE COATED CRYSTALS
- #2 LOCAL NON-UNIFORMITY
- #3 IN-SITU CALIBRATION WITH MIP
- #4 IN-SITU CALIBRATION WITH ISOLATED ELECTRONS
- #5 POINTING IN THE LONG. SEGMENTED CRYSTALS

• Effect of Nonuniformity on the Resolution

ORNL



Uniformity for different λ_{att} and transparent front facet (for side facets F=1.) MgF2(thin film) + Al coating

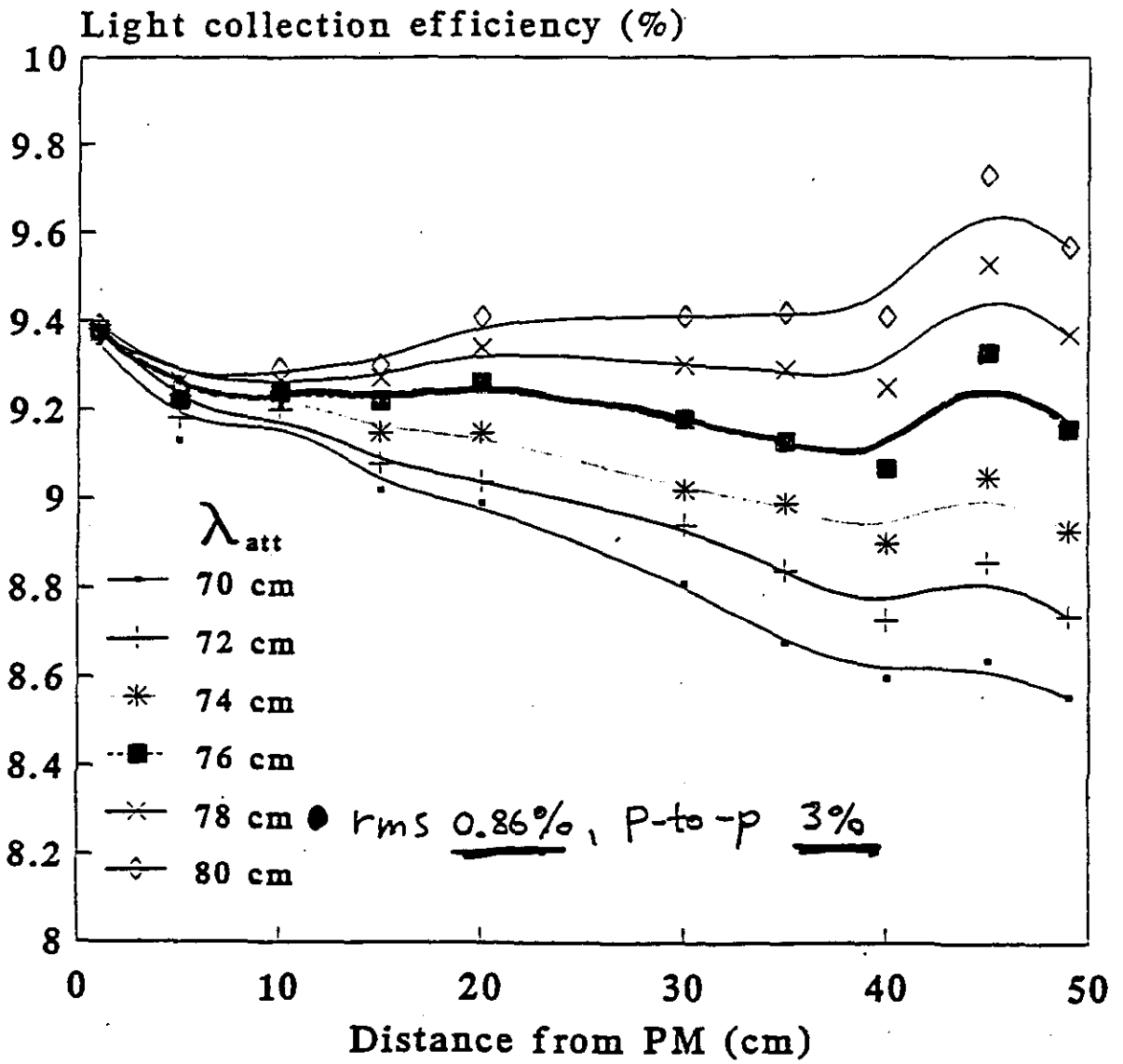
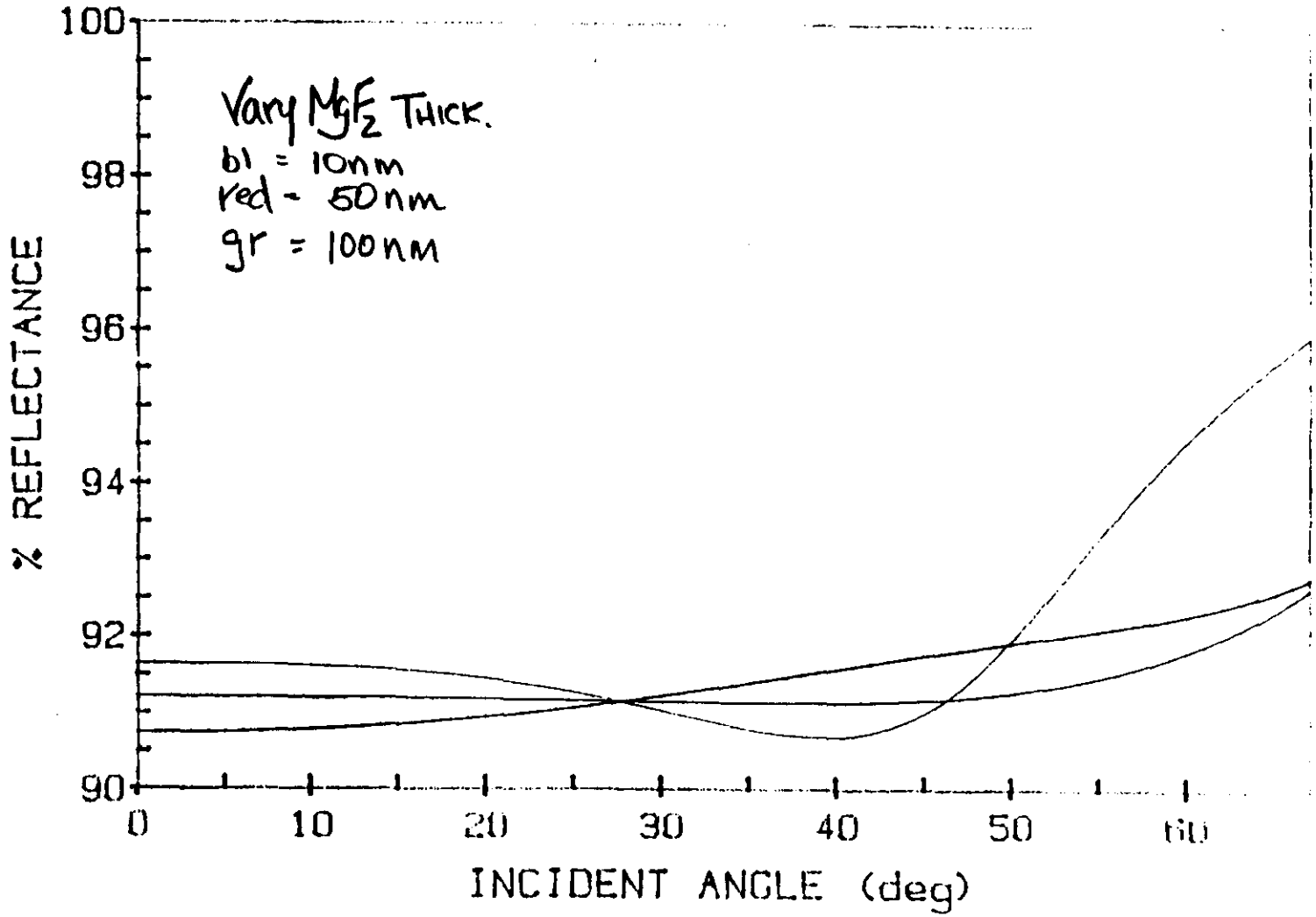


Fig 1-7 (b)


Vary MgF_2 THICK.
bl = 10nm
red - 50nm
gr = 100nm
% REFLECTANCE
100
98
96
94
92
90
0
10
20
30
40
50
60
INCIDENT ANGLE (deg)

BaF2 UV Reflective Coatings

Milestones:

July 1:
1. Aluminum coatings deposited on BaF2 samples < 20 cm long.
2. Measurements made on front-surface and back-surface reflectance versus wavelength.
3. Data supplied to ORNL for Monte Carlo.
4. Long term aging of coatings under study.
5. Outside vendors identified for coating 15,000 crystals, costing done.
6. Measurements begin on light collection versus length for "old" Chinese 50 cm crystal. No coating.

July 7:
1. New coatings prepared for scatterometry and reflectance measurements
2. Aging tests begin.
3. Measurements continue on 50 cm crystal light collection versus length for different wrappings/coatings. Data to be supplied to ORNL for LTRANS benchmarking.

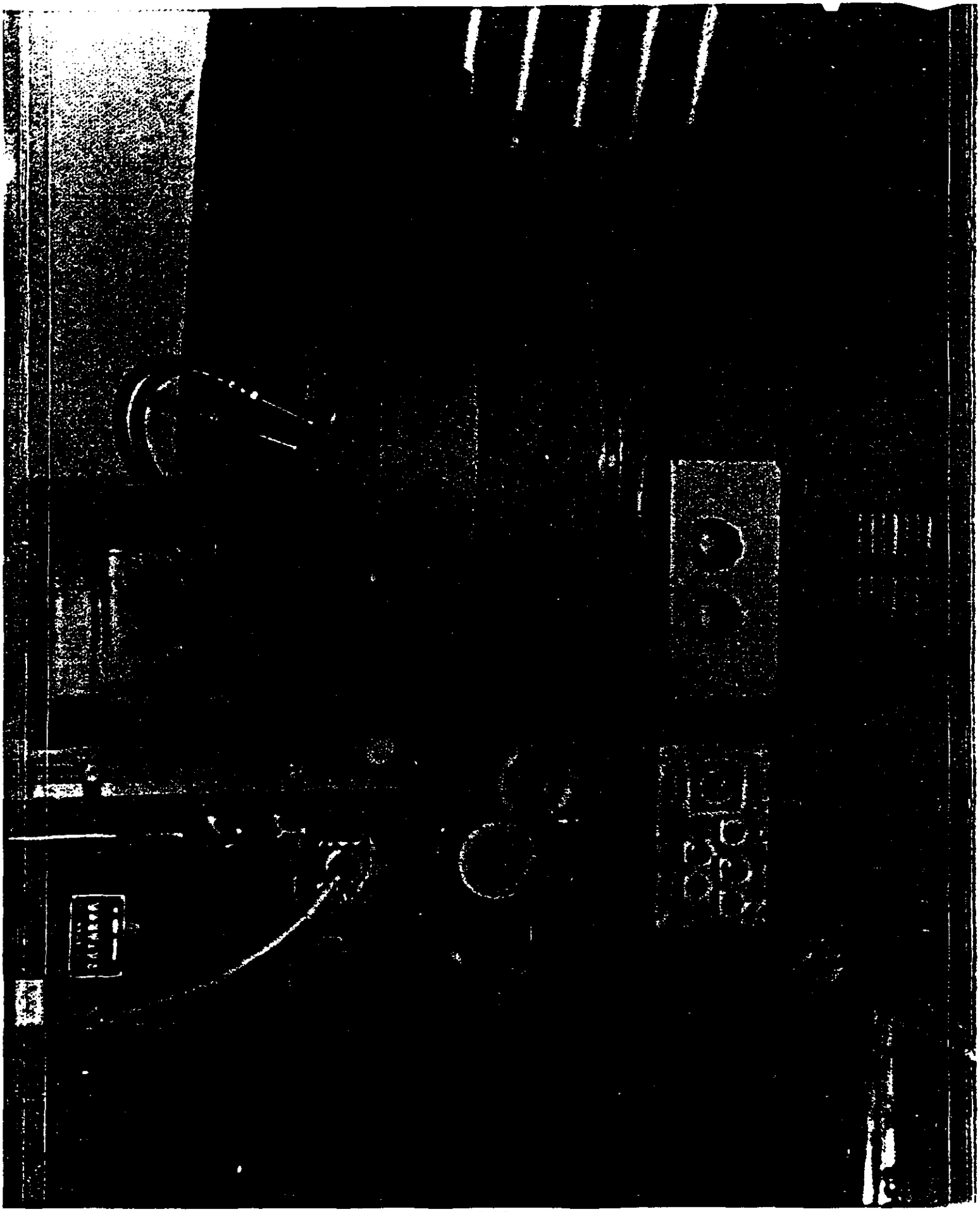
Aug. 1:
1. Aging test results becoming available.
2. Scatterometry results available for Monte Carlo.
3. Incorporation of FILMSTAR into LTRANS for reflectance curves.
4. 50 cm long crystal coated by outside vendor and measured, data supplied to ORNL for LTRANS benchmarking.

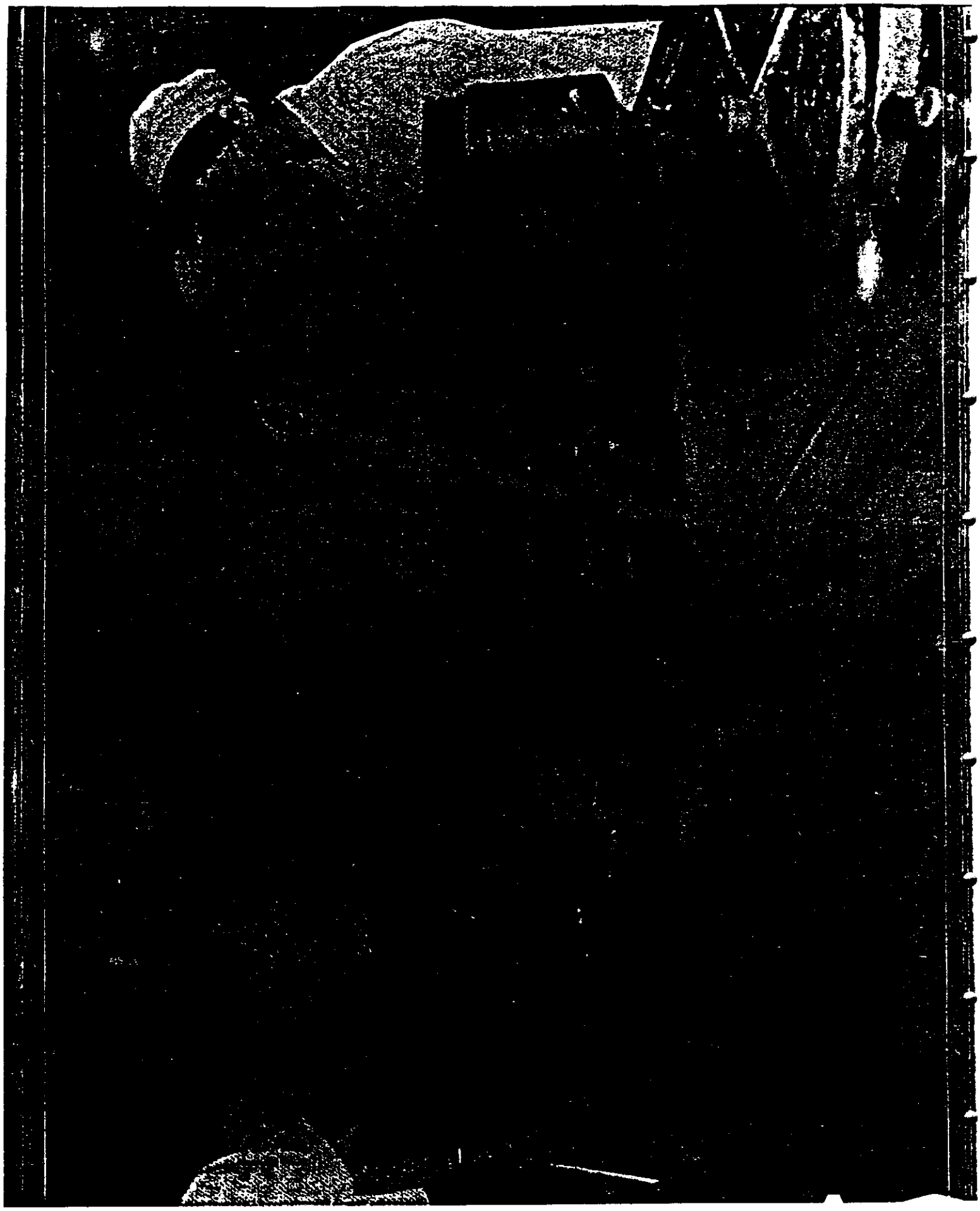
→ Aug. 9:
1. Begin process to coat small samples with non-uniform reflective coatings.

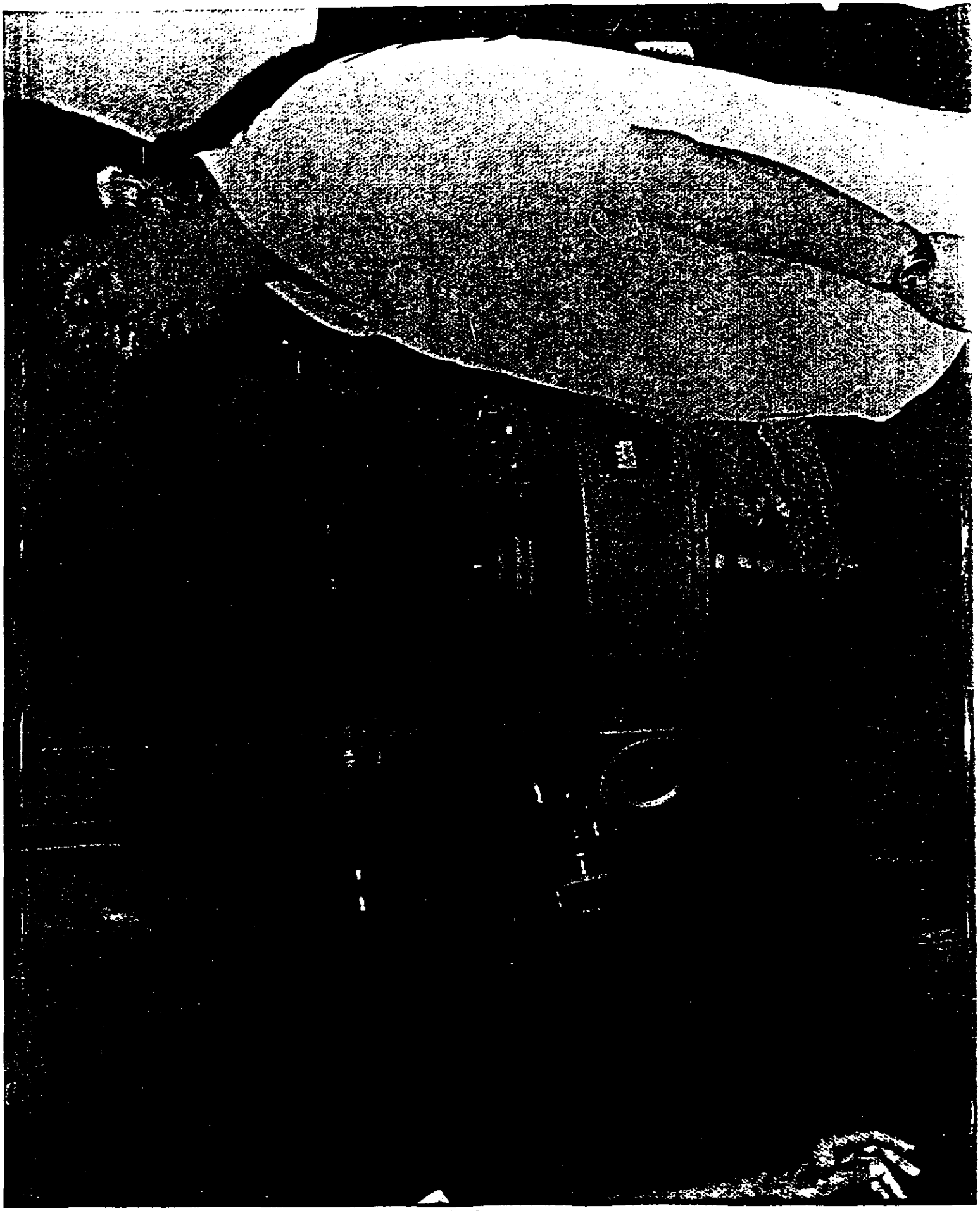
→ Sept 2:
1. Coat 50 cm long crystal with non-uniform reflective coating using data from experiment and calculations to define functional form for reflectance vs. length.

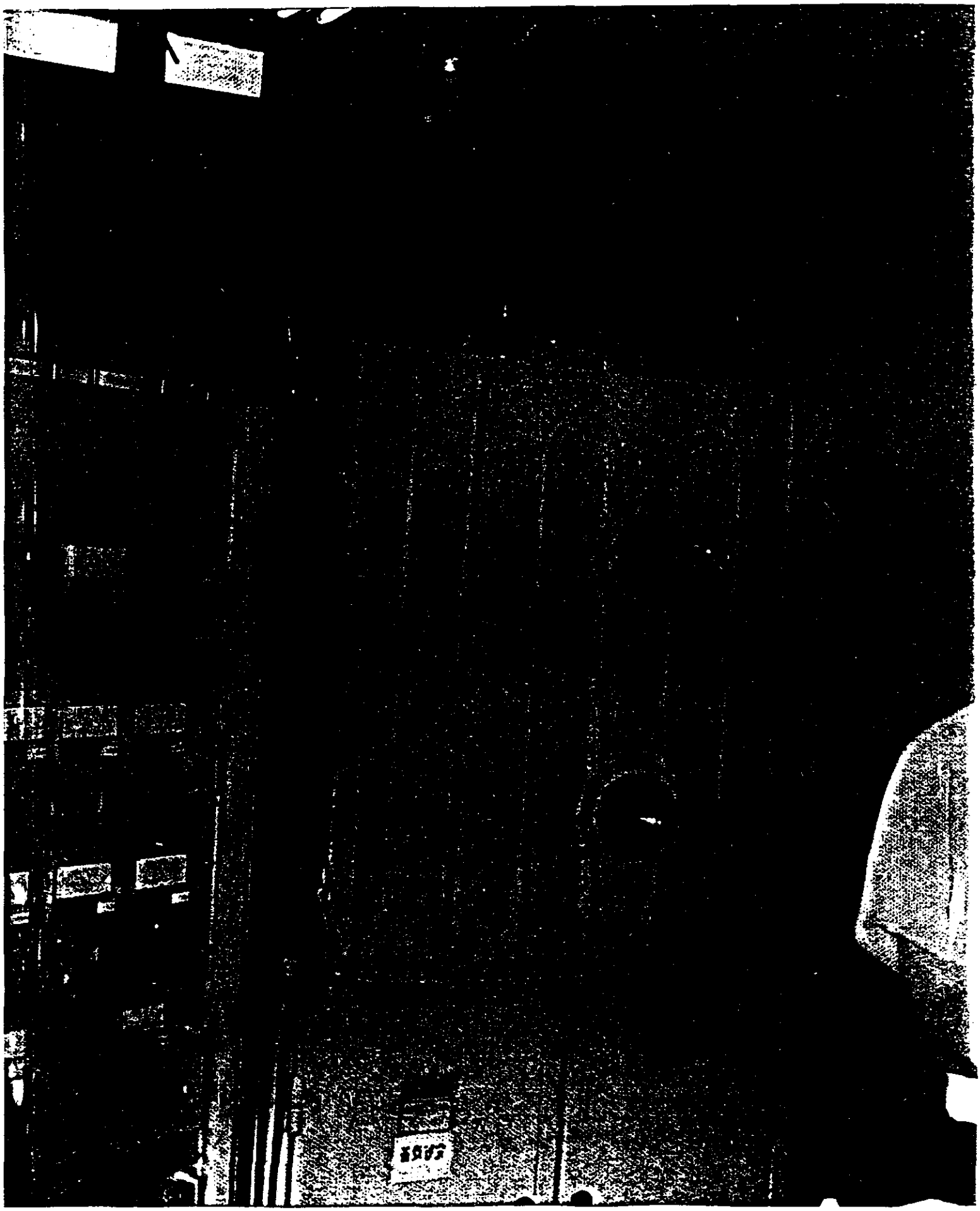
BaF_2 R&D STATUS (JULY 1992)
CRYSTAL MANUFACTURING PLAN

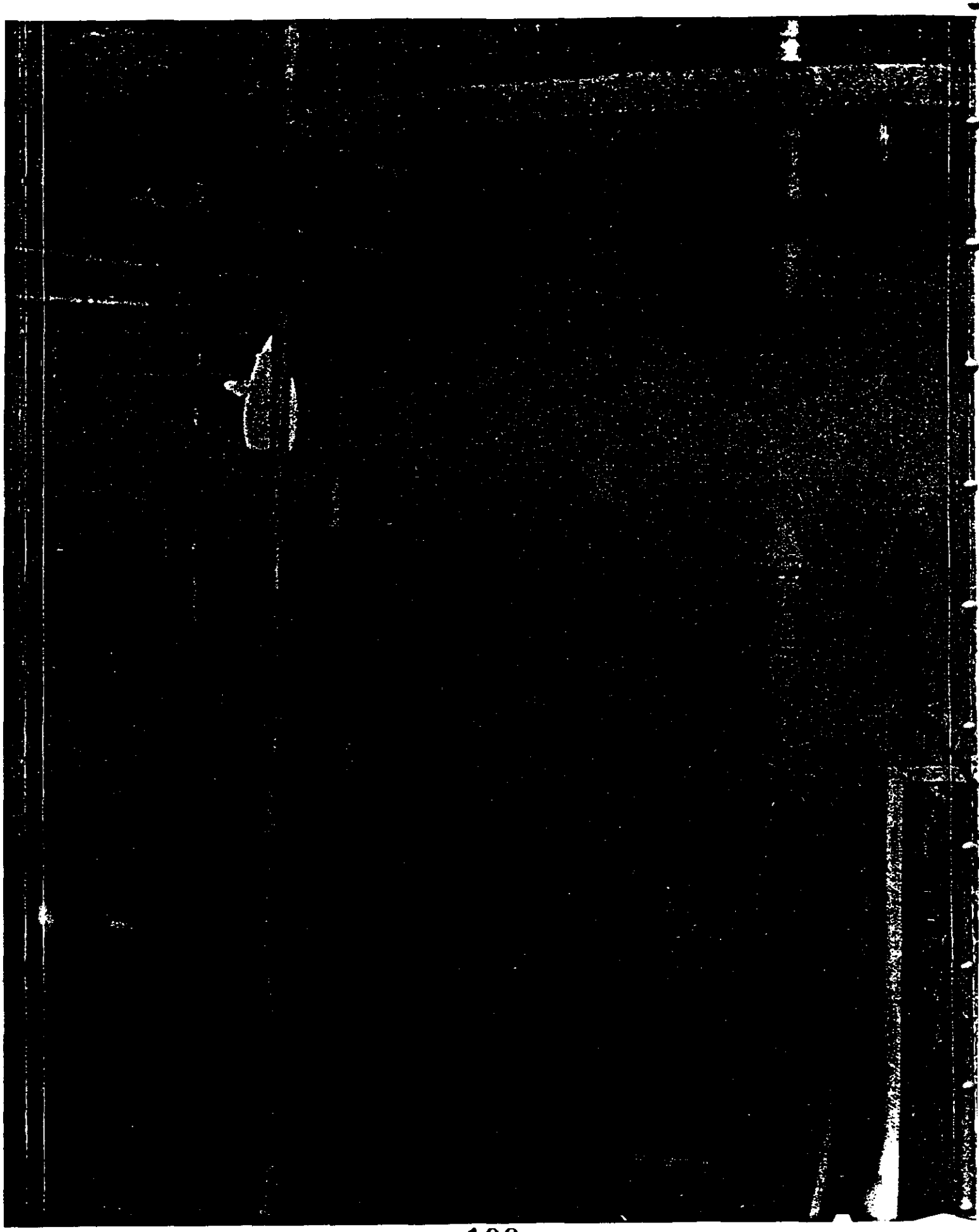
- CRYSTAL GROWTH: SIC, BGRI
- MECHANICAL PROCESSING AND INSPECTION: ZHONGNAN OPTICAL INSTRUMENT FACTORY
  - LoI for Full BaF_2 Production Signed July 14
  - Mass Production: 15 Pairs Per Day, For 3 Years.
  - Precision Cutting, Lapping, Polishing, and Optical Inspection Machines (1 μm, 1 μrad) Available
  - → Technology Transfer from LLNL: Final Lapping and Polishing Process
  - → Large Inductive Multipoint Inspection Machine (L3 Type), To Be Built at Tsinghua Univ.
- MECHANICAL STRUCTURE: TSINGHUA UNIVERSITY (ORNL)
  - CO_2 Laser Beam Welding of 100 μm Titanium Alloy Foils
  - Proposal for Complete 7×7 Precision Prototype Structure for $ 30K.
  - → Laser Welded Samples Meeting Specifications By Mid-August.
- → UV REFLECTIVE COATING: ZHONGNAN, BGRI (LLNL)
  - Production With BGRI 4 Meter Coating Tank
  - Technology Transfer from LLNL
- → QUALITY CONTROL and BENCH TESTS: IHEP BEIJING

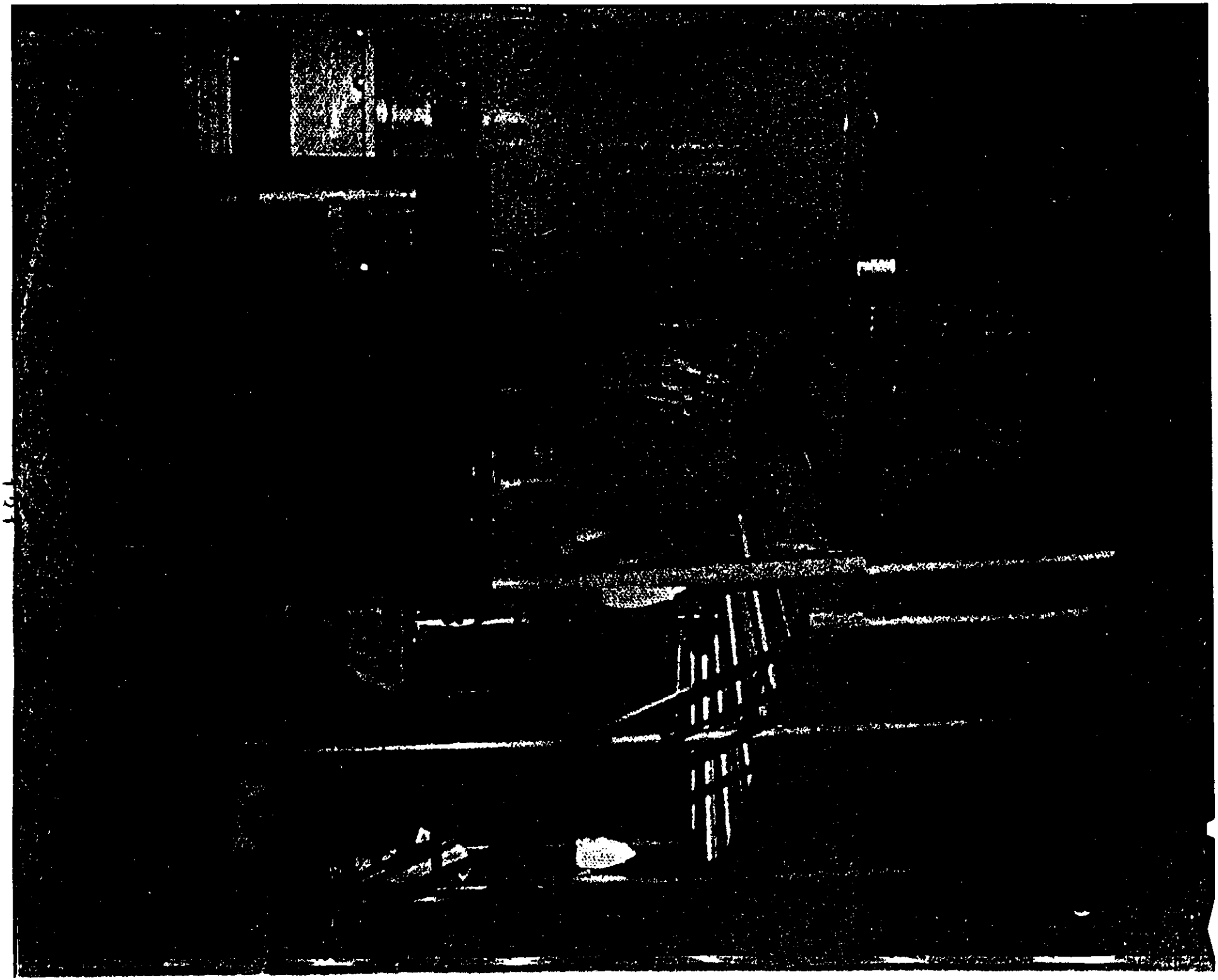












LETTER OF INTENT
BY
BARIUM FLUORIDE COLLABORATION
TO
ZHONGNAN OPTICAL INSTRUMENT FACTORY
FOR COLLABORATION ON THE PRECISION MACHINING AND POLISHING OF BARIUM FLUORIDE CRYSTALS

Representing the Barium Fluoride Collaboration:

Dr. Craig R. Wuest
Lawrence Livermore National Laboratory
for
Professor Harvey Newman, Spokesman
for Barium Fluoride Collaboration
California Institute of Technology

Representing the Zhongnan Optical Instrument Factory:

Mr. Zhang Chunyuan,
Zhongnan Optical Instrument Factory
for
Mr. Song Shubin, Chief Director
Zhongnan Optical Instrument Factory

The conditions to be met are: 1) Successful demonstration of radiation resistant BaF_2, 2) Successful demonstration of machining and polishing of large BaF_2 crystal pairs, 3) Successful demonstration of reflective optical coating of BaF_2, 4) Acceptance of the BaF_2 Electromagnetic calorimeter by the GEM Detector Executive Committee, 5) Continued approval for funding of the SSC by the United States government.

Zhongnan Optical Instrument Factory is called upon to perform tasks in support of items 2) and 3). LLNL, BGRI and SIC are working to satisfy the requirement of item 1). Items 4) and 5) are somewhat beyond our control.

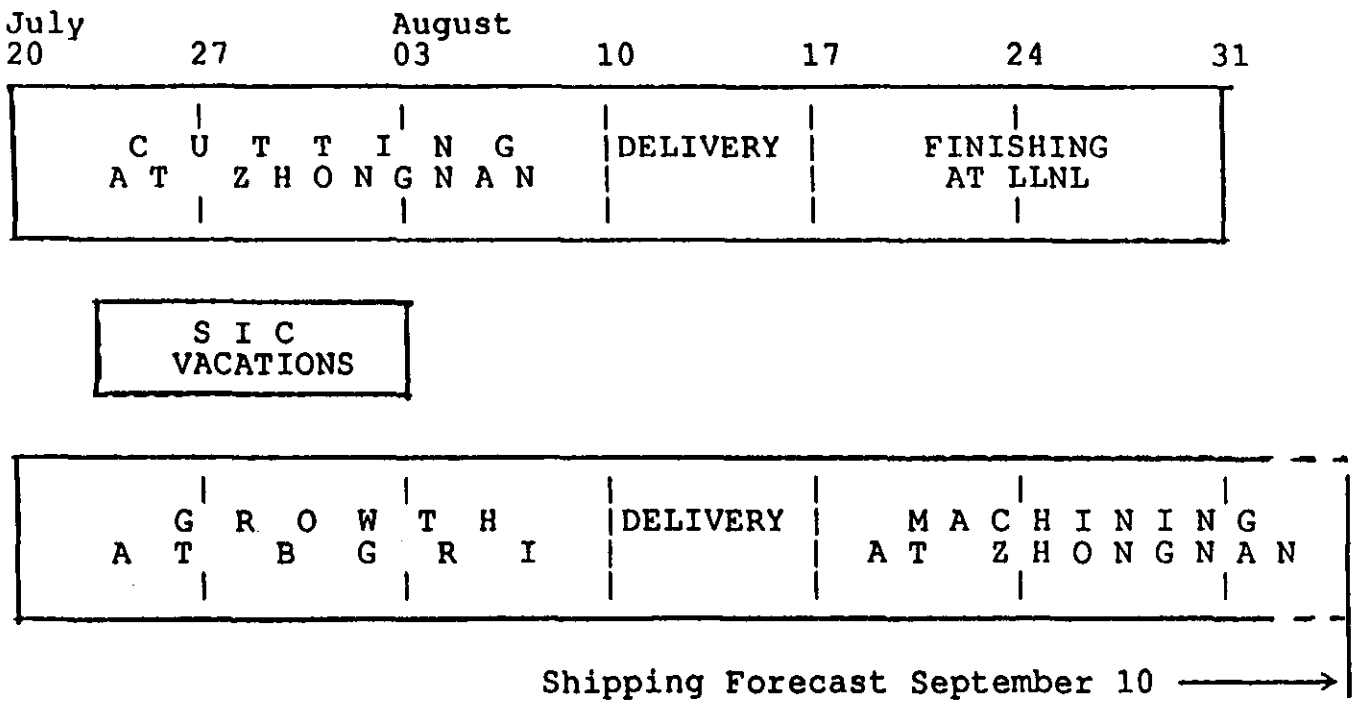
Because of time constraints, we are reducing our short term goal to produce 5 crystal pairs. It

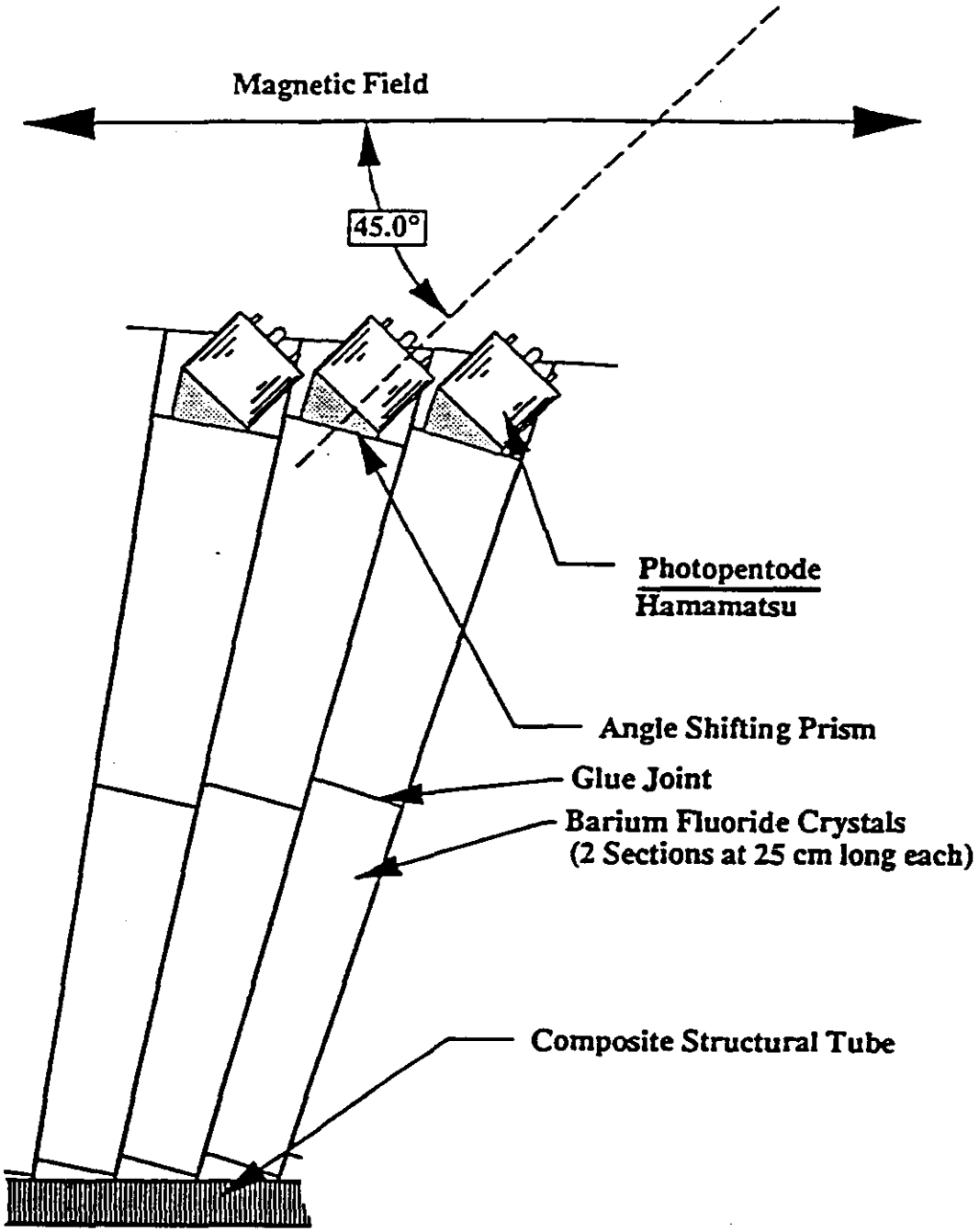
BaF_2 R&D STATUS (JULY 1992) ZHONGNAN OPTICAL INSTRUMENT FACTORY

Zhicheng, Hubei Province, China

- High Precision, Medium Precision Telescope Lenses, Mass Produced Optics (600 K Pieces Per Year)
- Precision Diamond Sawing, Grinding, Lapping and Polishing Machines Available
- Full Sized BaF_2 Crystals Already Processed: Cutting Speeds 2-3 mm Per Minute
- Optical Inspection Facility: Dimensions, Angles, Parallelism, Perpendicularity, Surface Roughness, Flatness, Internal Stresses, UV/VIS Transmission
- SHORT TERM PROGRAM:
  - Precision Cut, Diamond Polished Pair: Begun 7/20; Delivered To LLNL For Inspection By 8/10
  - Precision Polished Crystal Piece Coated At Zhongnan: 1250A° Al, 2500A° SiO_2
  - Provide Five Unpolished Crystal Pairs. To Be Finished, Inspected At LLNL; Tested At CE&A.

CUTTING SCHEDULE AT ZHONGNAN (M. LEBEAU)





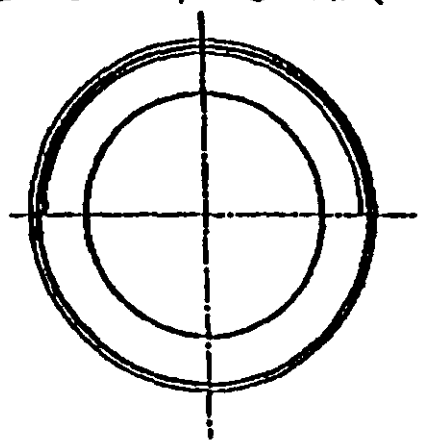
Barium Fluoride Readout

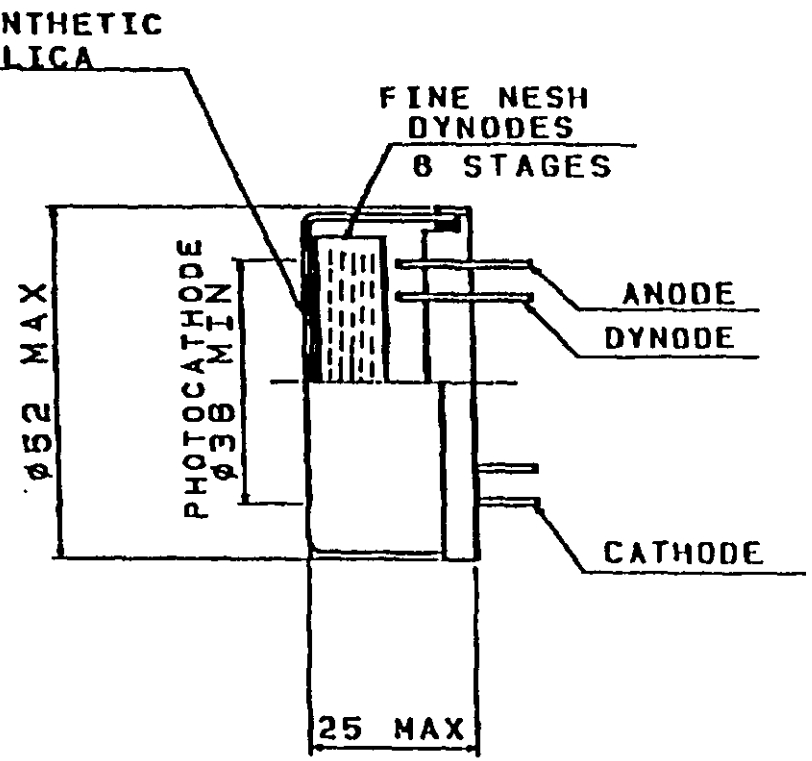
• NEW HAMAMATSU PROXIMITY FEW STAGE TUBE

ATT. BOB.
RE: CAL TECH / PROX PMT.

- GAIN ≳ 30
- 25 mm THICK

→ QE (220nm) ≥ 10%
→ RbTe OR KCsTe Photocathode
→ ACTIVE AREA ϕ36 mm (→40 mm)





GENERAL TOLERANCE	A	B	C
≤6	±0.10	±0.20	±0.30
6< ≤30	±0.15	±0.25	±0.50
30< ≤120	±0.25	±0.35	±0.80
120< ≤400	±0.40	±0.50	±1.40
400<	±0.60	±1.00	±2.00

MLT.	MARK	REASON	SIGN	DATE

MATERIAL 材料 | SCALE 尺度 1/1 | DATE 1982 · 8 · 18 | TITLE 題名 P-PMT5

QTY. 数量 | FINISH 仕上 | APPD. 承認 | CHECK 検図 | DESIGN 設計 | DFT. 製図

TOTAL 重量 | WEIGHT 重量 | HAMAMATSU PHOTONICS K.K. | DRAWING NO. 図面番号 K9206L

BaF_2 EM CALORIMETER SILICON AVALANCHE PHOTODIODE (APD)*

ADVANCED PHOTONIX, Inc. (API)

- BARE DIODE With Deposited Narrow Band UV Filter
- Q.E. To 80% (200 nm)
- RAD HARD (PD Tested to 0.4 MRad)
- LOW CAPACITANCE: 2-3 nsec RISE
- LOW NOISE: 0.25 nA/cm^2
- BUILT-IN GAIN (Use $\approx$ 200)
- VERY STABLE: TEMP. COMPENSATED (for -2%/°C)
- LARGE DYNAMIC RANGE
- MAGNETIC FIELD IMMUNE: COMPACT, NO TILT

Development: Delivery of Several Large Area Diodes from API: $ 50 K

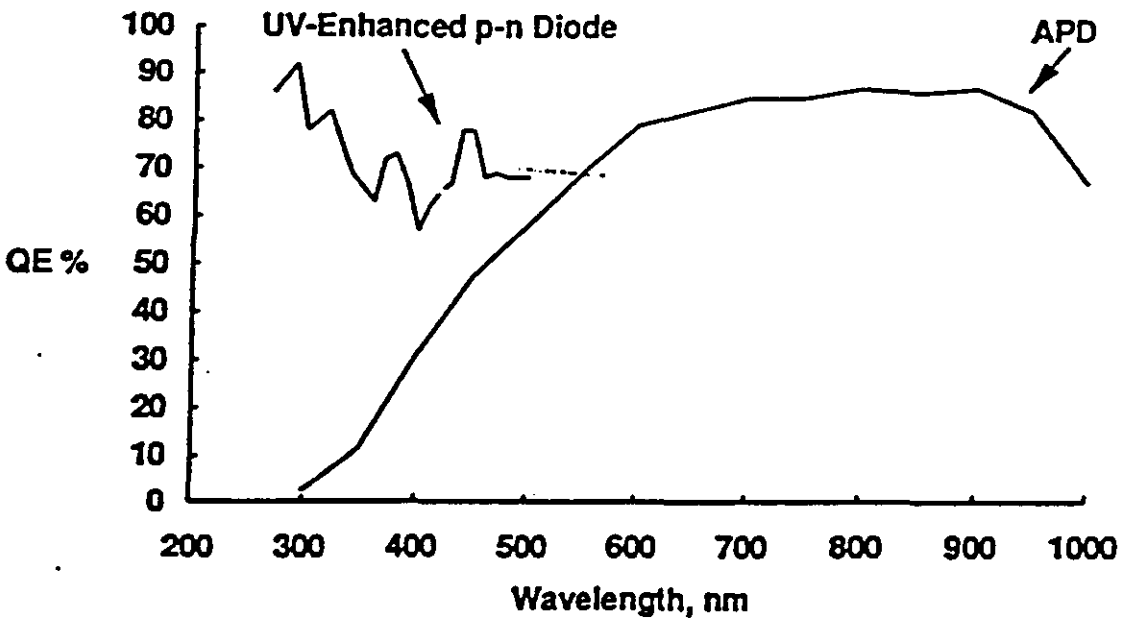
Other Vendors: Interest Expressed By Litton, Hughes, EG&G

→ BaF_2 With Two Long. Segments Under Study At ORNL, Caltech

TITLE OF PROJECT: Avalanche Photodiodes for Barium Fluoride Calorimetry at the SSC

TECHNICAL ABSTRACT (Limit to space provided.):

The proposed project will extend the spectral response of currently available large-area avalanche photodiodes (APDs) into the blue and ultraviolet. Coupled with barium fluoride, a fast, high-atomic-number scintillator, a superlative high energy photon and electron detector, capable of operating in the high-rate environment of the Superconducting Super Collider, will then be provided. A photodetector to be used with barium fluoride must have short-wavelength response down to 190 nm. Although large-area p-i-n diodes with extended-UV response are available from a number of manufacturers, they are unsuitable for use with shaping times much faster than 2 microseconds because of poor noise performance. In contrast, APDs give improved rather than degraded performance with fast shaping times (down to around 0.01 microseconds) but at present their photoresponse falls off below about 400 nm. Advanced Photonix currently produces reliable and low-noise large-area APDs, with high production yield. We believe that a straightforward R&D program will extend the photoresponse of these large-area APDs into the blue and UV.



Quantum efficiency *vs* wavelength for Advanced Photonix APDs, and for an Advanced Optoelectronics UV-enhanced p-n diode (measured at SDC)

BaF_2 CALIBRATION

- RFQ: Radiative Capture Photons
  - RFQ Test (3.85 MeV) At AccSys
  - L3 System (1.85 MeV) At LEP
- MIP Calibration
  - Test at UCSD Cosmic Ray Stand
- UV Laser Monitoring System (CMU, UCSD)
- Check: Inclusive $Z^0, \Upsilon \rightarrow e^+e^-$

ACCSYS
TECHNOLOGY, INC

1177 Quarry Lane
Pleasanton, CA 94566
(415) 462-6949
FAX: (415) 462-6993

GEM Barium Fluoride Crystal Calorimeter Calibration System

The barium fluoride (BaF_2) crystal calorimeter proposal for the GEM detector at the SSC Laboratory will be calibrated on-line using an RFQ linac to bombard a target with an intense pulsed proton beam to produce burst of photons. The present proposal for this RFQ calibration system can be satisfied by the AccSys Model PL-4 linac system operating with an H^- output beam that is stripped to H^0 in a gas neutralizer for transport into the center region of the detector through the magnetic field.

A drawing of the prototype Model PL-4 RFQ linac is shown in Fig. 1. This system, now being tested, is being developed for the U.S. Navy as a neutron generator. It is capable of a peak output current of more than 40 mA. The Navy unit uses an H^+ ion injector, but could be just as easily used with the H^- ion injector shown in Fig. 2. This rf driven H^- ion source is an upgraded version of the one in use at CERN for calibration of the BGO crystal calorimeter of the L3 experiment. A contract has been signed by AccSys with DESY to fabricate this H^- injector for use on the Linac III system at HERA.

As seen in Fig. 2, the ion source and acceleration gaps are mounted inside the grounded vacuum chamber for safety and to allow the hydrogen gas load from the ion source to be easily pumped away. The power from the ion source equipment cabinet to the injector is fed through an insulated tube, allowing the equipment cabinet to be located remotely for easy service and maintenance during operation of the accelerator within an experimental area.

The 35 keV H^- beam extracted from the ion source is transported and focused into the RFQ linac through a low energy beam transport (LEBT) system that uses two solenoid magnet lenses. The calculated beam optics design for the LEBT shows that the beam from the injector can be focussed properly into the RFQ using modest field magnets.

The H^- ion beam from the injector will be accelerated to a final energy of 3.85 MeV using a 3 m long RFQ operating at 425 MHz. This RFQ accelerator, used for the Model PL-4, was originally developed to generate neutrons for non-destructive testing, and was designed to be rugged and reliable. The detailed specification of this system are listed below:

MODEL PL-4 RFQ LINAC

- $H^- \rightarrow H^0$
  Radiative Capture
  $\mathcal{J}_0 \approx 40$ GeV "Equivalent"
  Per Pulse

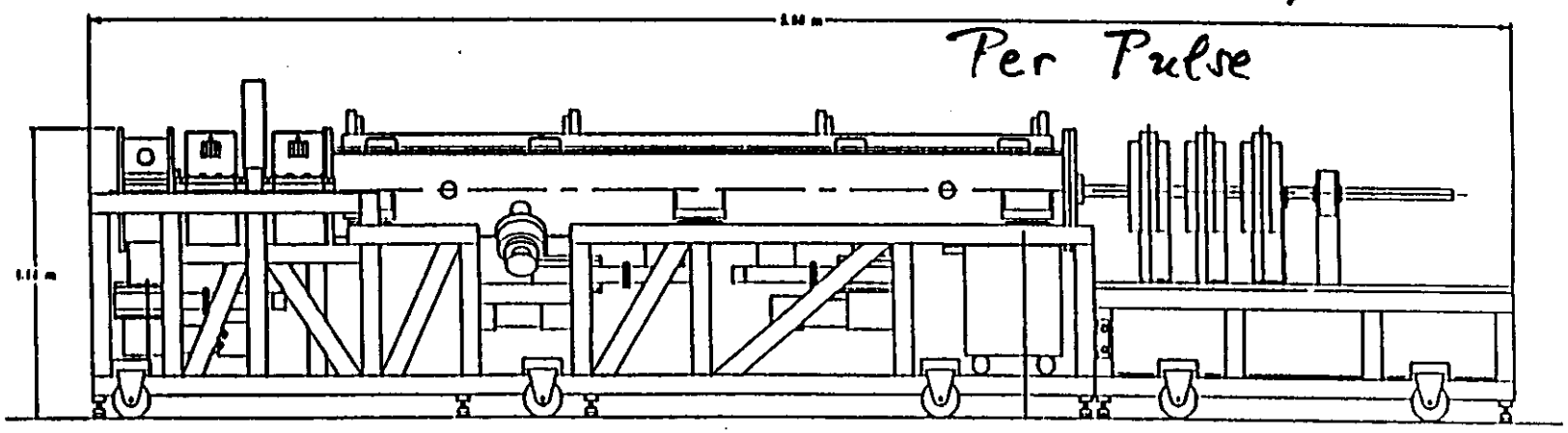


Fig. 1 - Drawing of prototype Model PL-4 linac

ACCSYS

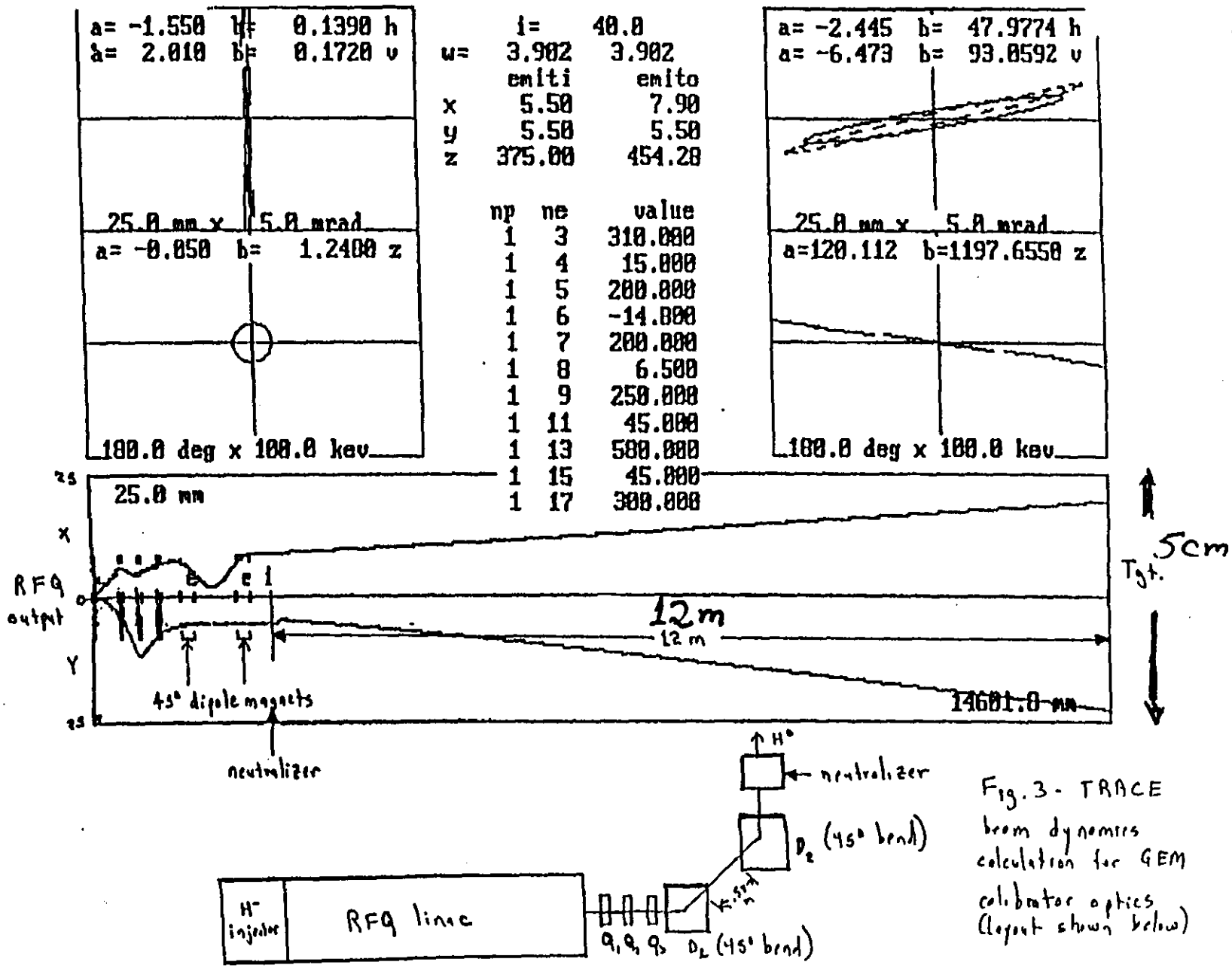


Fig. 3 - TRACE beam dynamics calculation for GEM calibrator optics (layout shown below)

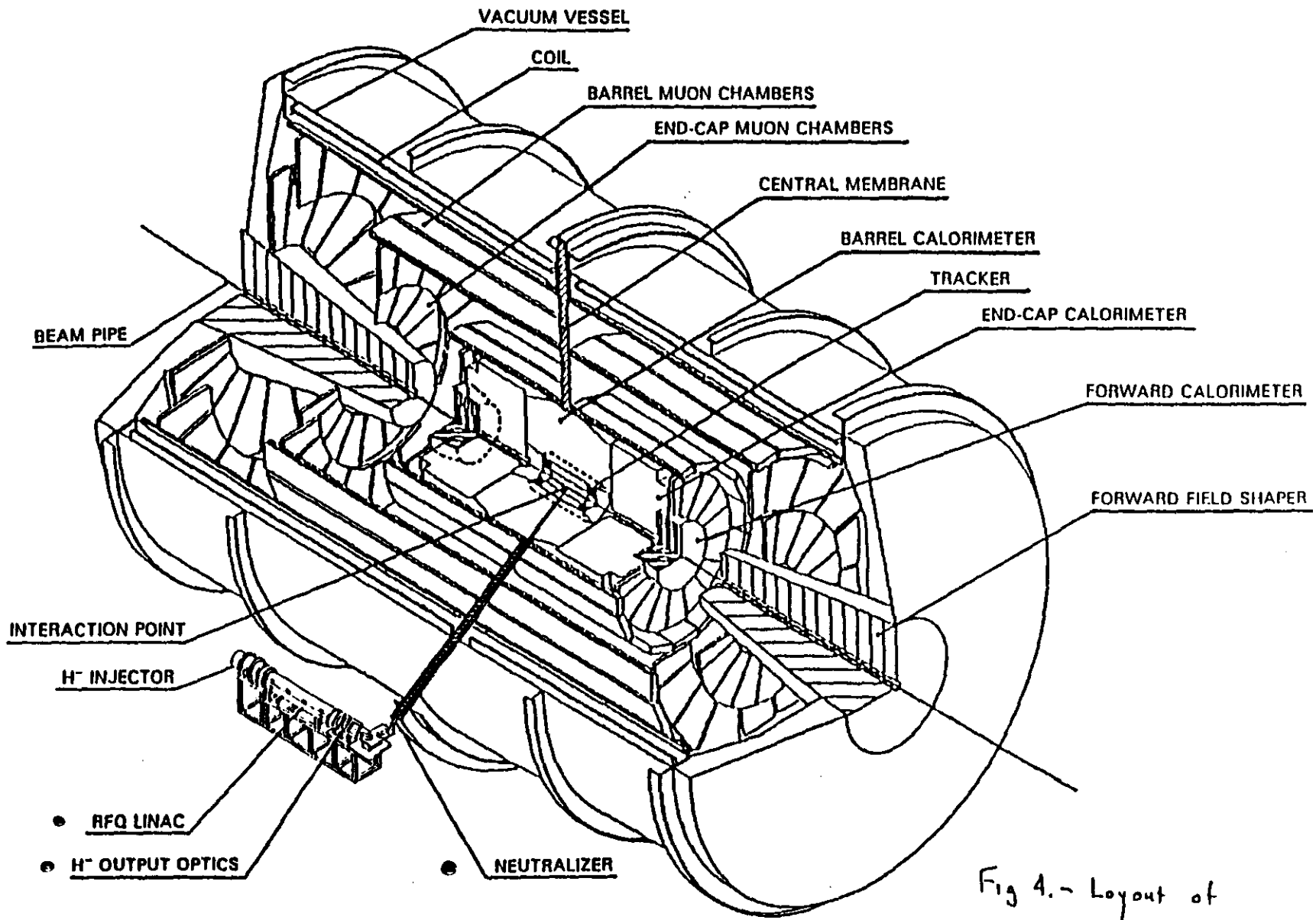
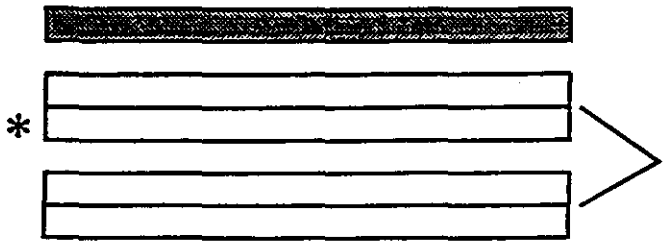


Fig 4.- Layout of GEM experiment with Model PL-4 RFQ Calibrator.

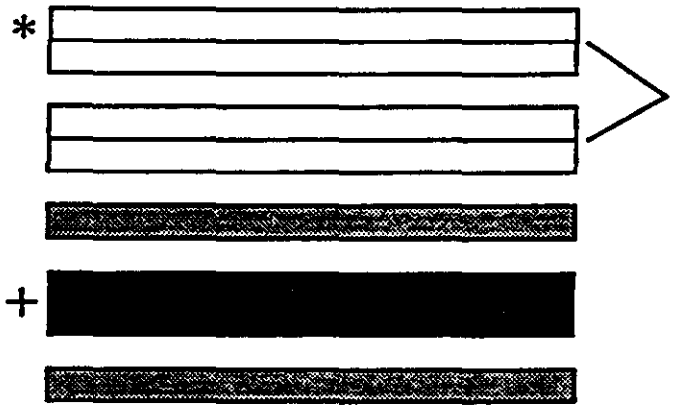
BaF_2 Cosmic Ray Test Stand



1.0 x 1.5 m scintillator

576 x 384 wires, 2mm spacing

(1.3 x 1.0 m) x 1.0 m test space



576 x 384 wires, 2mm spacing

1.0 x 1.5 m scintillator

0.2 m steel

1.0 x 1.5 m scintillator

* = broken wires

\+ = ~~not~~ ready (7/92)

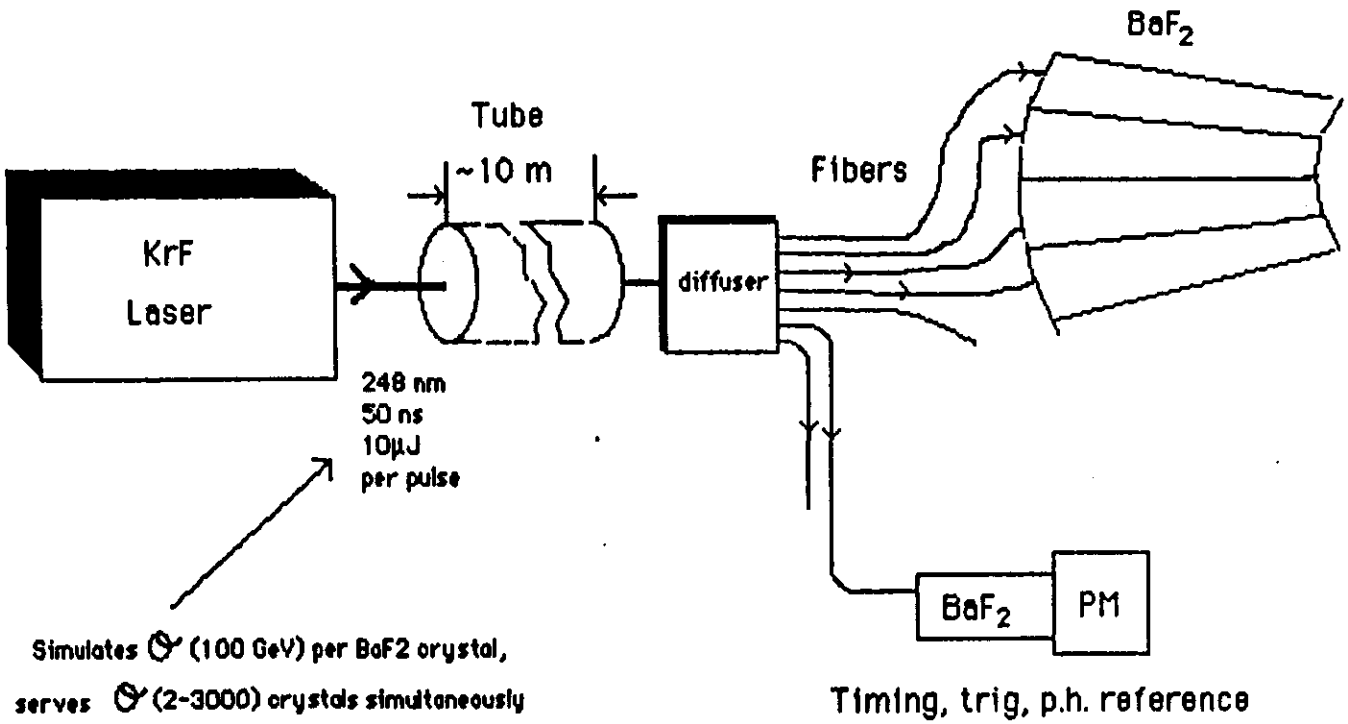
BaF_2 COSMIC RAY TEST STAND
Status as of July 1992

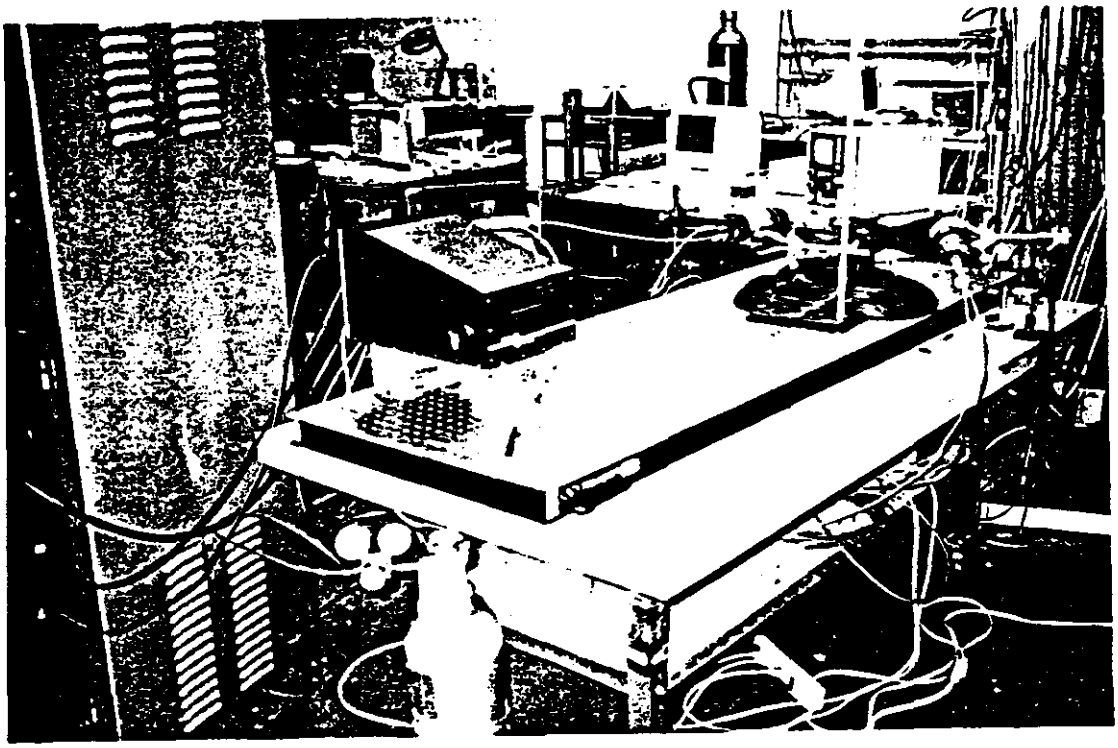
- Hardware
  - Mechanical Structure ..... Complete
  - Triggering Counters ..... Complete
  - Defining Counters ..... Complete
  - Trigger Logic ..... Complete
  - Data Acquisition Logic ..... Complete
  - PWC Mechanical (*) ..... Complete
  - PWC Electrical ..... Complete
  - PWC Readout ..... Complete
  - PWC Gas ..... Complete

- Software
  - Data Acquisition ..... Complete
  - Chamber Monitoring ..... Complete
  - Tracking ..... In Progress
  - Crystal Studies (res., noise) ..... In Progress

- Near Future
  - First Crystal Data ..... Mid August
  - Routine Crystal Data ..... Late August

- UV Laser + Quartz Fiber Monitoring System (CMU)





CMU : COMPACT KrF Laser (248nm)

- $10\mu J$ ⇒ to 3 GeV Equivalent *
  (Lab Model)
- Production Model : To TEV RANGE
  (10 - 50 mJ)

* Optical Fiber, Diffusion.

BaF_2 MONITORING
ULTRAVIOLET FLASH LAMP

- Flash Width - 3 ns FWHM
- Wave length - 220 nm center, 25 nm FWHM
- Intensity
  - 20,000 - 60,000 p.e. after 1 m fiber
  - 150 - 300 fibers per flash lamp
- Proposal for Monitoring Relative Gain Stability
  - 1 fiber per crystal
  - 50 - 100 flashtubes for 15,000 crystals
  - 50 - 100 crystals have fibers from two flash lamps
- Proposal for Monitoring Gain and Global Linearity
  - Two sets of flash lamps
  - 2 fibers per crystal
  - 100 - 200 flash lamps for 15,000 crystals
  - 50 - 100 crystals have fibers from 4 flash lamps

UV Flasher System
Status as of July 1992

- Hardware
  - UV Flash Lamp ..... **Complete**
  - Enclosure ..... **Complete**
  - Reference Enclosure ..... **Complete**
  - Fibers ..... **Complete**
  - Trigger Logic ..... **Complete**
  - Data Acquisition Logic ..... **Complete**

- Software
  - Data Acquisition ..... **Complete**
  - Analysis ..... In Progress
  - Preamplifier Studies ..... In Progress

- Measurements
  - First Pulse Shape ..... **Complete**
  - Routine Crystal Data ..... Late August
  - Matrix Monitoring Setup ..... Under Design

TOTAL P.04

"Panel" Meeting In Late August

- PRODUCTION of LARGE CRYSTALS IN CHINA
- SMALL RAD HARD CRYSTALS from LLNL, OPTOVAC
- Data Relating Microstructural Materials Properties to Rad Hardness: CE&A
- COSMIC RAY TOWER + UV MONITOR DATA
- SIMULATIONS + TEST DATA On UV UNIFORMITY
- CALIBRATION SIMULATIONS

* In Situ ANNEALING TESTS

- Participation of Chinese Representatives Yin, Li Wang

gem

γeμ

Presentation by:

Bill Worstell

Preliminary Beam Test Results from a Copper/Scintillating Fiber GEM Hadron Calorimeter Prototype

Bill Worstell

for the SSCintCal Collaboration

Team:

- ✓ Boston U.
- Drexel U.
- ✓ Fairfield U.
- Louisiana State U.
- ✓ Michigan State U.
- ✓ ORNL
- ✓ Texas A+M U.
- Texas Tech. U.
- ✓ U.C. San Diego
- ✓ U. Iowa
- ✓ U. Mississippi
- ✓ U. Tennessee

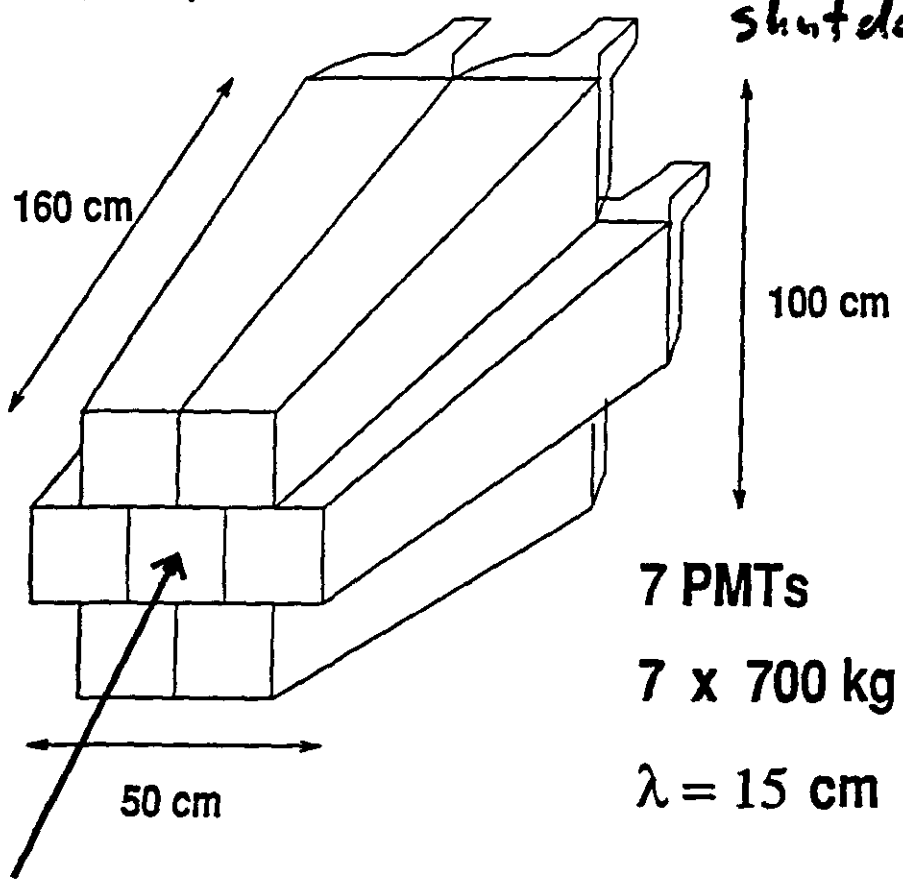
GEM Collaboration Council Meeting

SSC Laboratory

August 5, 1992

Copper Design — 4/92
7 towers at BNL — 7/17/92
First parasite beam — 7/24/92
First dedicated beam — 7/27/92
shutdown — 7/31/92

BNL A3 Beamline
1-20 GeV e, π, μ



7 PMTs

7 x 700 kg towers

$\lambda = 15$ cm

Rad-hard fibers (3HF)

Moveable Table:
- Horizontal
- Vertical
- +- 5° pitch to 10° pitch on top towers
- +- 3° yaw

Drift Chamber
Fiber Hodoscope
Muon Paddle
Calibration System
Forward Calorimeter Modules

pitch = vertical

yaw = horizontal

~ 24 hours dedicated beam

~ 48 hours parasite beam

Measurements:

Electrons:

1) Response vs. energy and angle
2) Relative and absolute calibration of modules
3) Light yield (2 methods)
4) Scan across crack between modules
5) Pulse shape

Pions:

1) Response vs. energy and angle
2) Scan across crack between modules
3) Compensation (e/ π --> e / h) vs. energy
4) Pulse shape
5) Longitudinal fluctuations / punch-through

Muons:

1) Response vs. angle
2) Scan across crack between modules

Also – No time for fiber testing/sorting.

quickly available materials { 2.25 % Packing fraction (instead of 3%)
7 mm fiber spacing → 8 mm spacing

Baseline

CAVEATS:

1) All results are PRELIMINARY, and in fact are taken from on-line distributions (photocopied from logbook)

2) No leakage corrections have been applied for the hadron shower data

3) Angular effects are important for electron showers, and we have not yet fully simulated for the incident angles used in our calibration runs

Therefore, the relative and especially absolute calibration scales are approximate as yet (e/h measurements are only indicative)

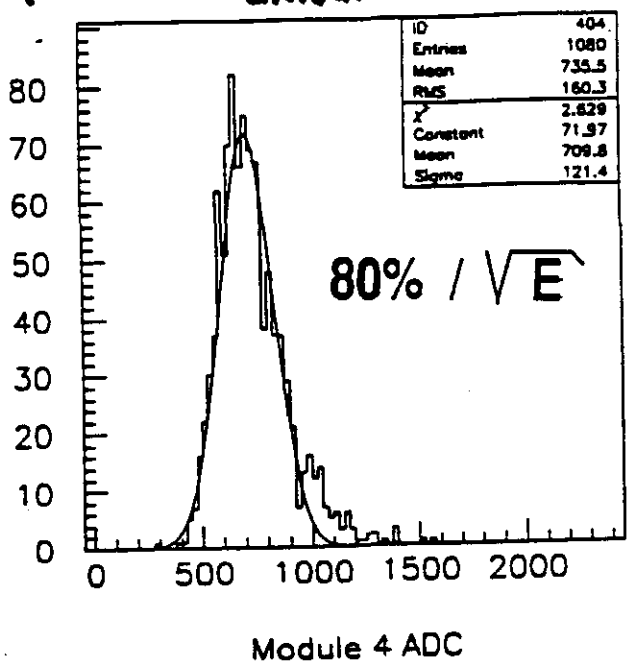
15 GeV Electrons

PRELIMINARY

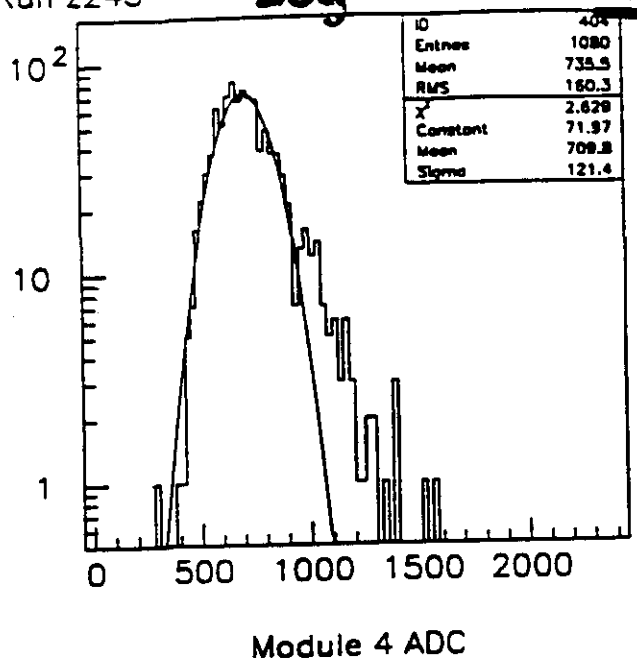
Angle effect (small angles) for electrons

15z GeV Run z243

Linear



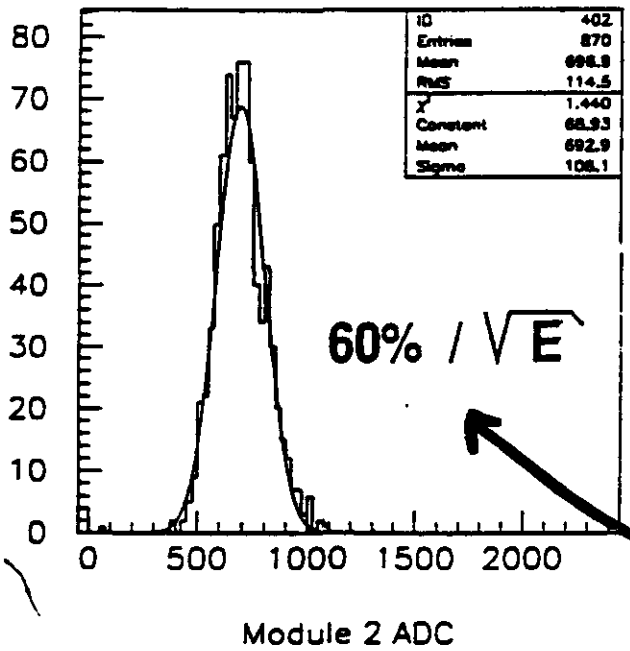
Log



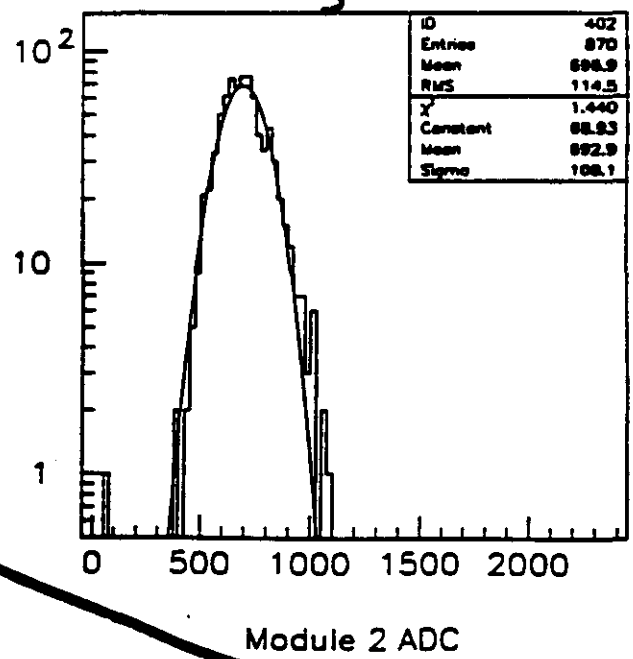
Pitch = 5° Yaw = 3.5°

15z GeV Run z245

Linear



Log



Pitch = 10° Yaw = 3.5°

Further improvement expected for photons

Electron Results:

1) Resolution for PHOTONS must be established by Monte Carlo after checking to match electron data (spec = 40%/sqrt{E})

baseline

Resolution for electrons < 60% / sqrt{E} at large angles

2) Light yield > 60 PEs/GeV with rad-hard fibers (spec = 40 PEs/GeV)

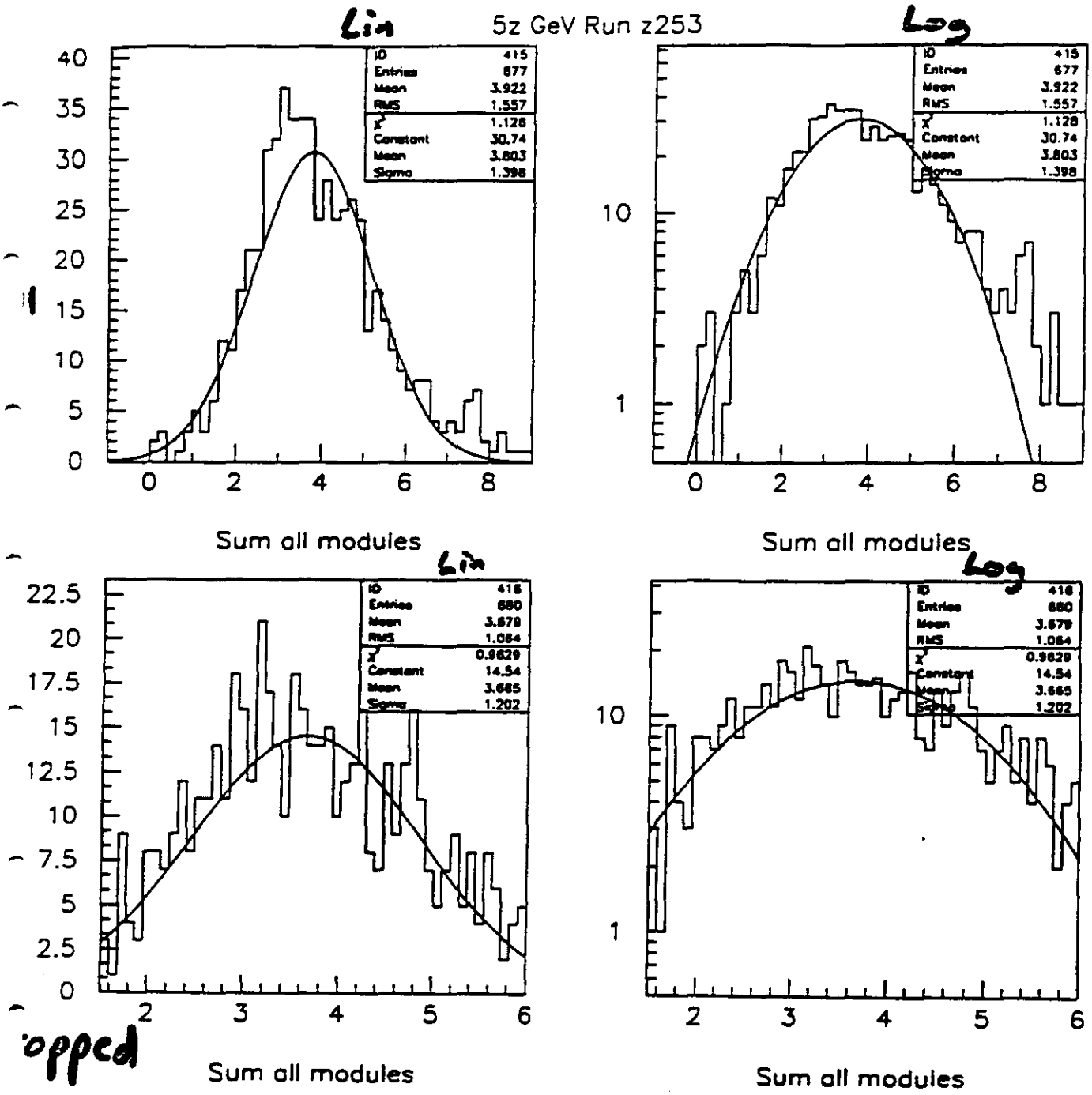
3) Scan across crack at 11 degree angle with respect to fibers gives no measured "dip" in output (< 5%)

Modulo relative calibration

PRELIMINARY

5 GeV Pions

7 module sum

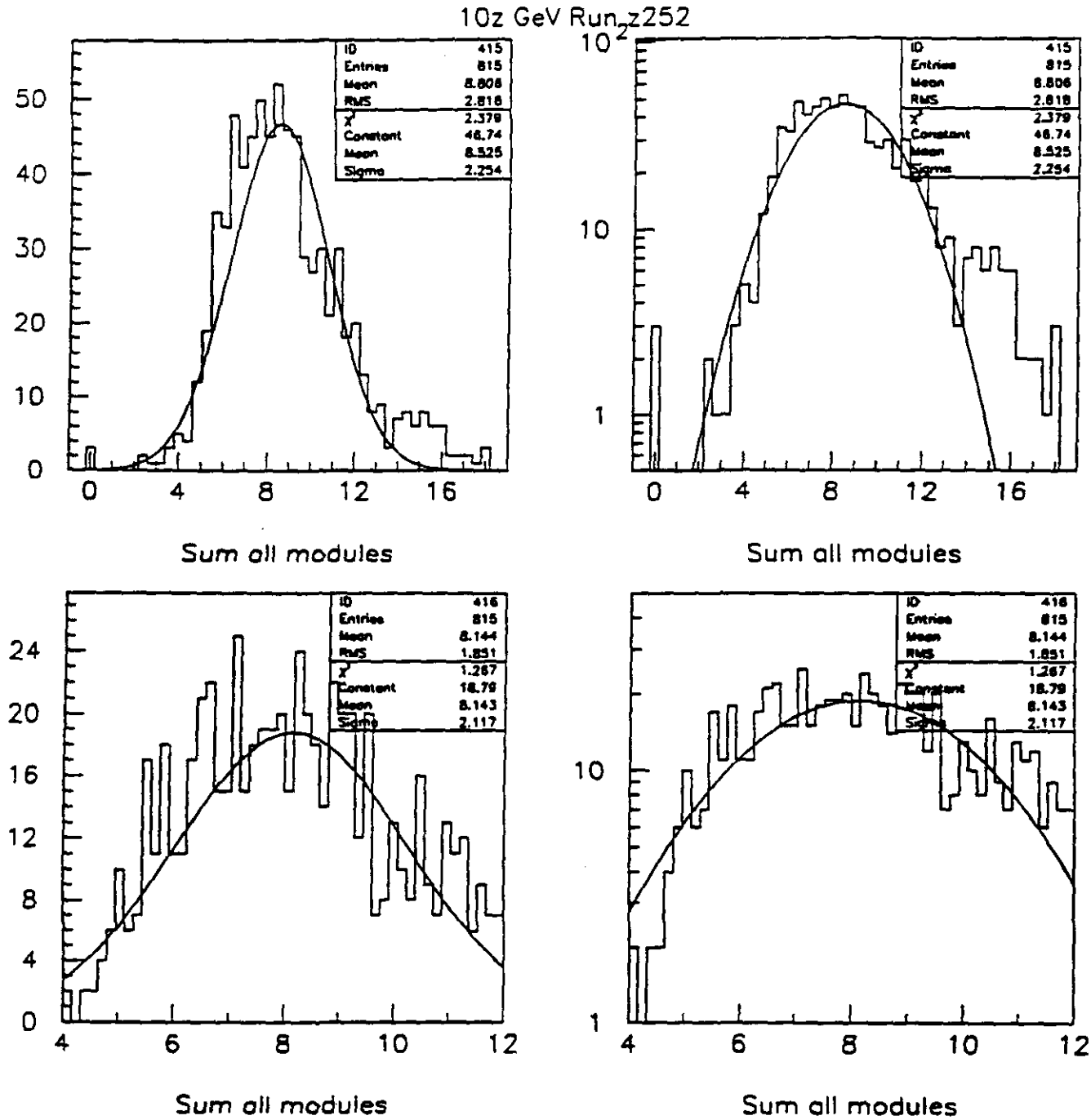


RAW DATA

No leakage corrections

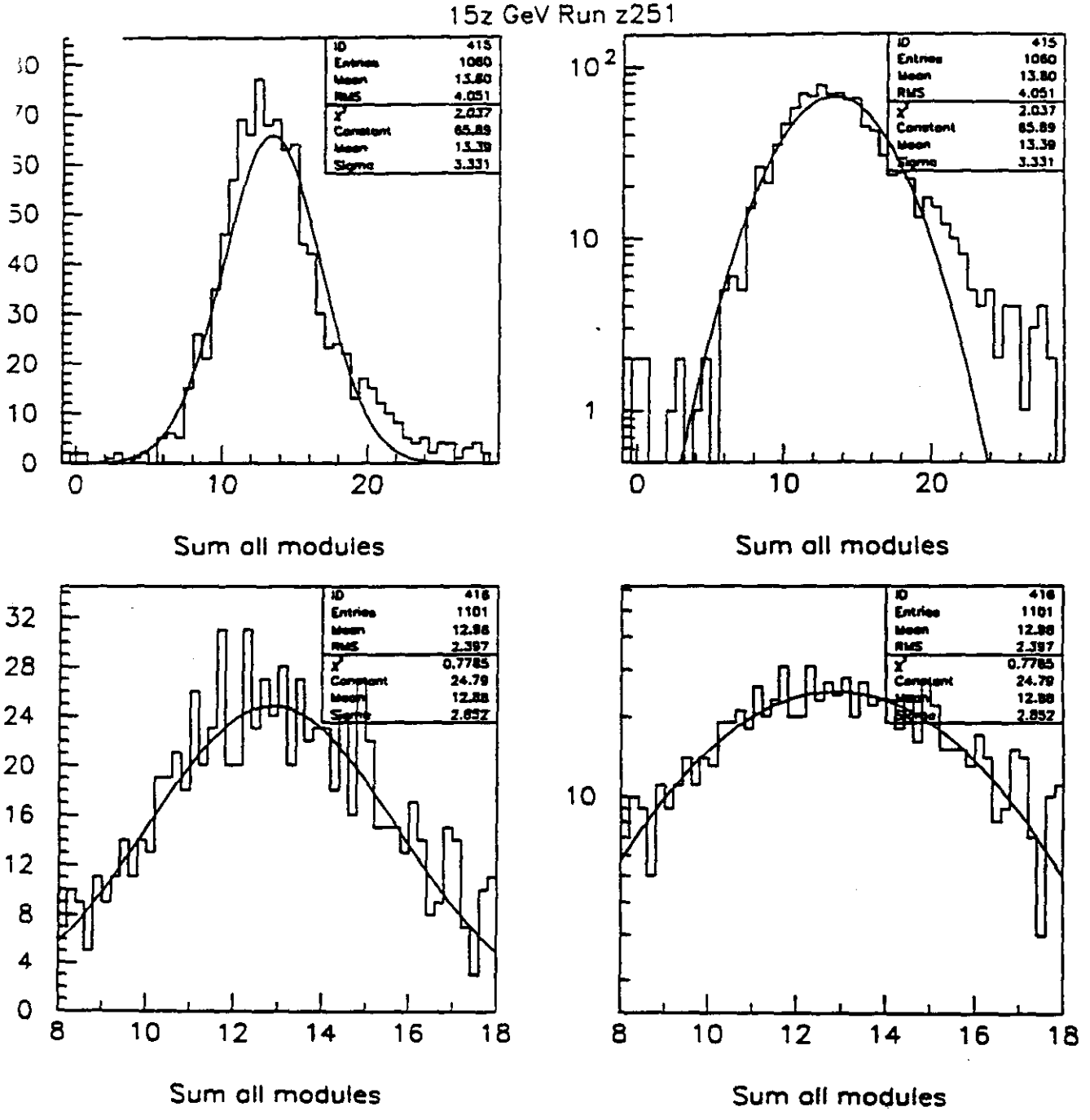
PRELIMINARY

10 GeV Pions



15 GeV Pions

PRELIMINARY



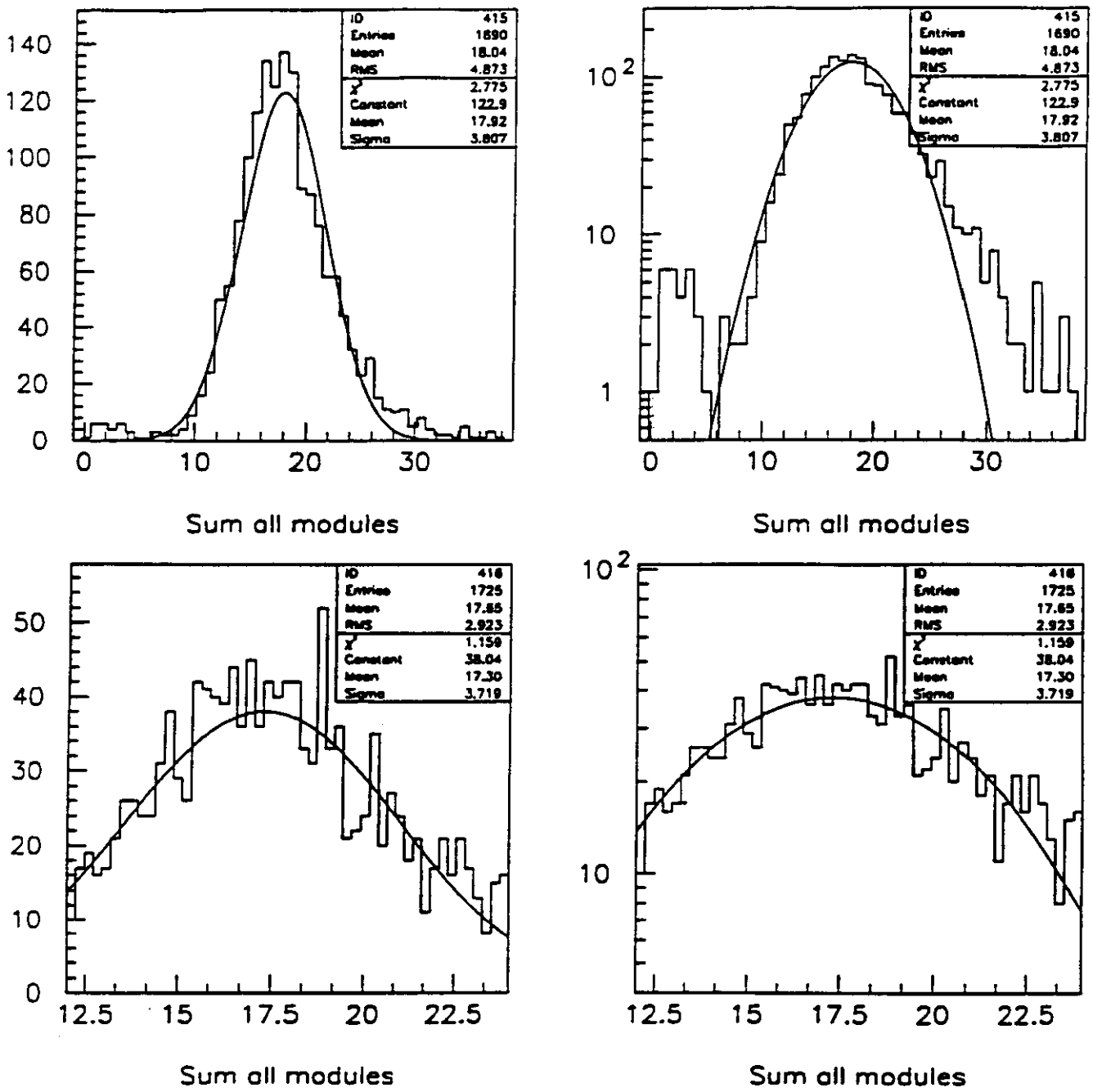
PRELIMINARY

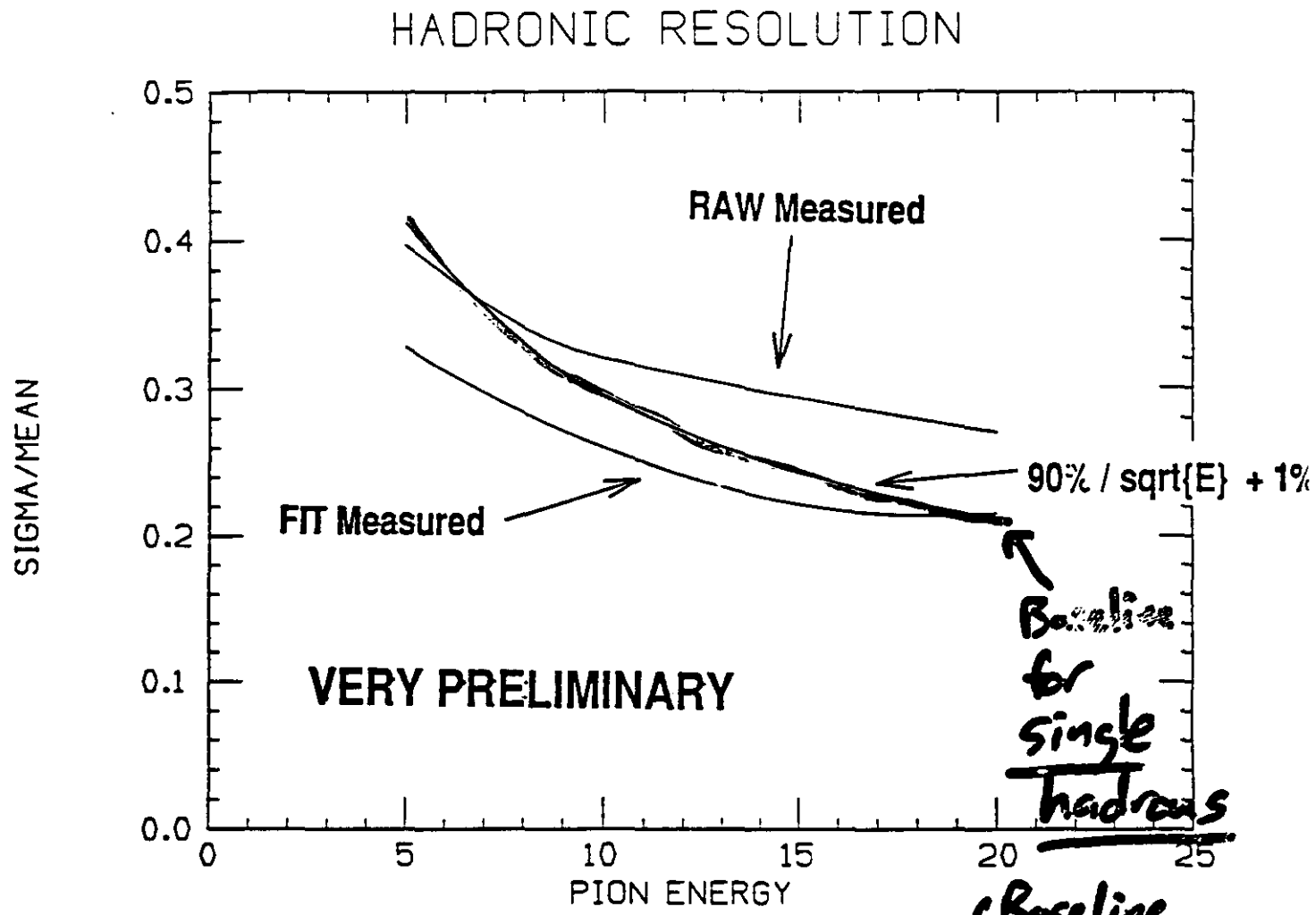
20 GeV Pions

ONLINE

RELATIVE + ABSOLUTE CALIBRATIONS

20z GeV Run z277





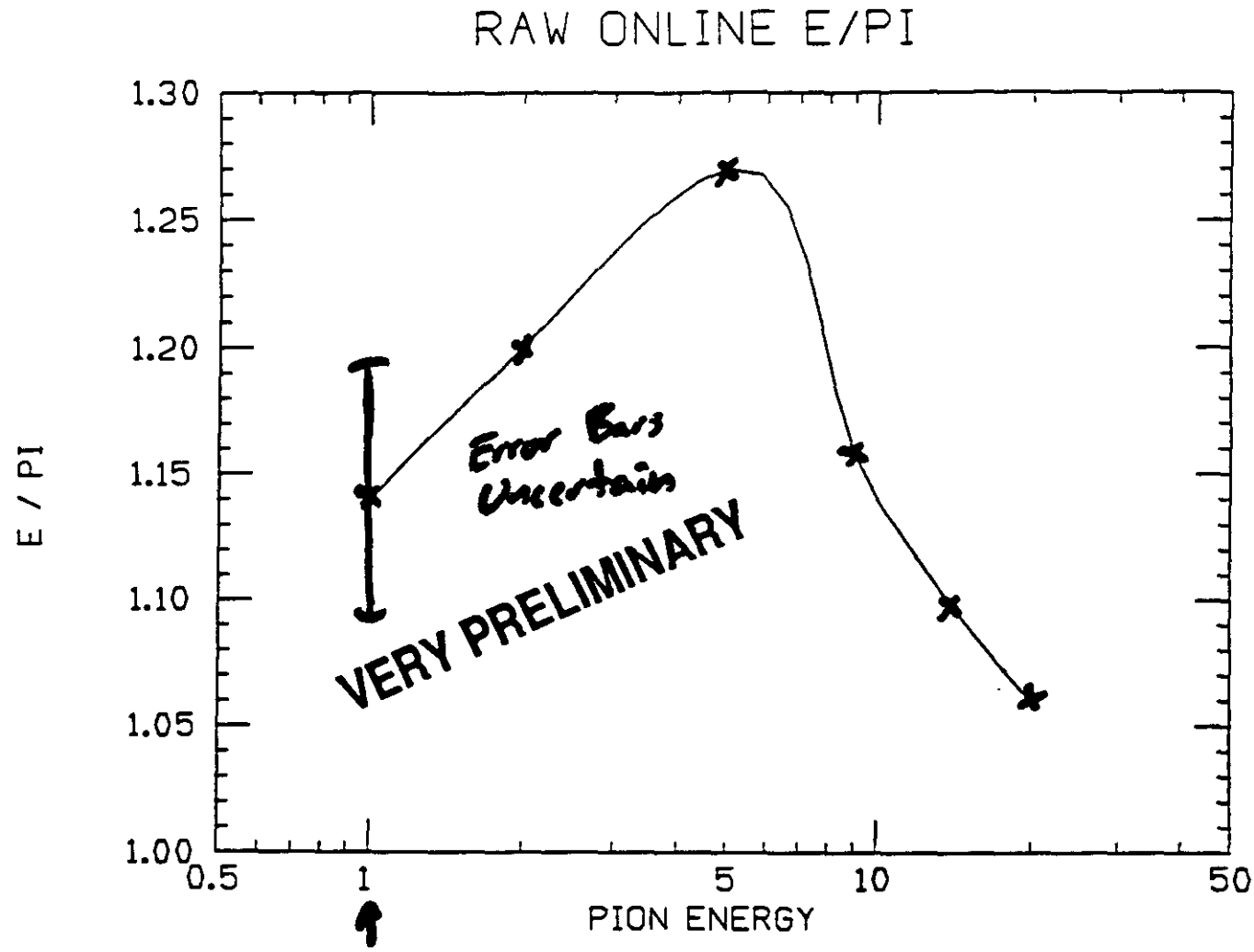
(Baseline jets = $\frac{75\%}{\sqrt{E}} + 1\%$)

Online Relative Calibrations

No Leakage Corrections

Must fold in angles,
1.5 λ upstream (BaF_2)

Leakage significant at high energies



No Leakage Corrections

Must fold in angles,
1.5 λ upstream (BaF_2)

~90% containment (?)
must check

Table Limits

Beam axis 1° from center tower axis, 3 cm from center position

Preliminary

Pion results:

1) Resolution for pions must be established by correcting the measured resolution for leakage effects, but appears to be in the right ballpark

2) We have preliminary indications of compensation at high energies, but e/h measurements require considerable refinement (leakage, calibration, etc.)

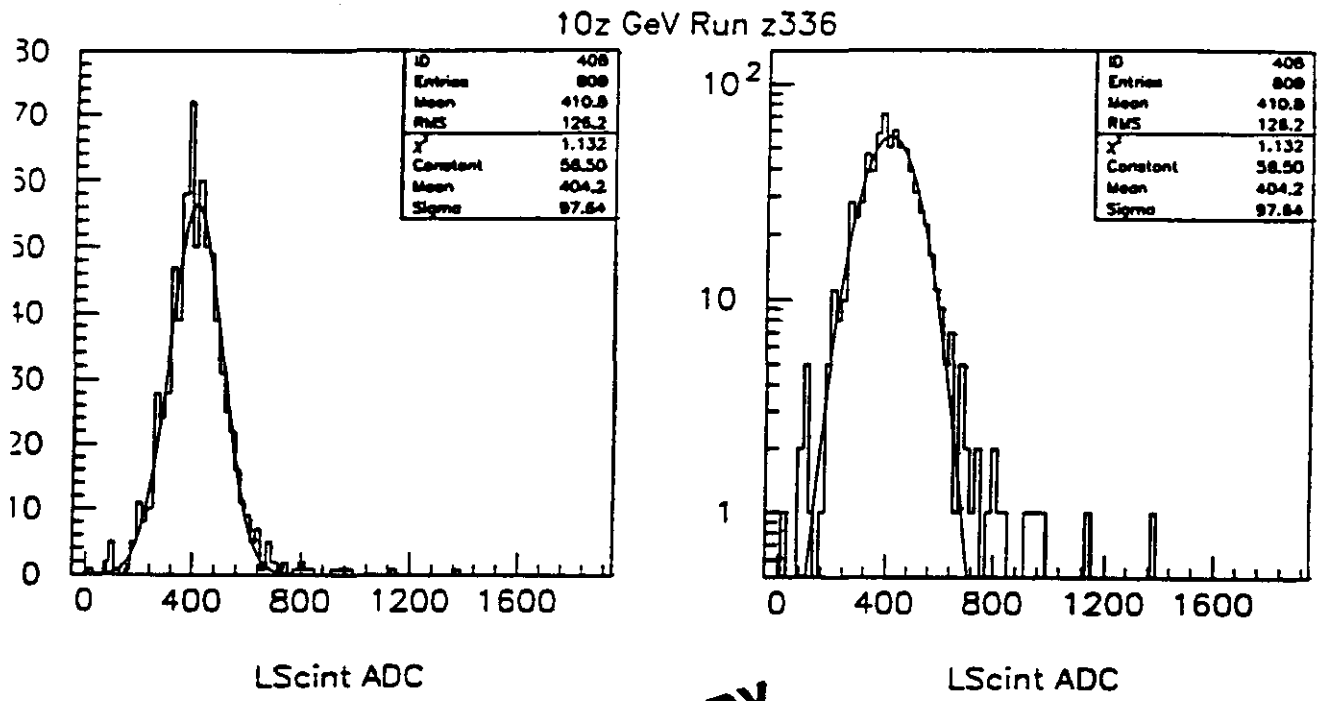
3) No measured effects from changing pion incident angle and position relative to cracks beyond that expected from leakage variations

THIS ANALYSIS WILL REQUIRE SOME TIME AND CARE, BUT NOW WE HAVE THE DATA

QUARTZ FORWARD CALORMETER

(Cherenkov only)

10 GeV Electrons



PRELIMINARY

Fiber angle = 9 degrees from beam axis (Pitch)
~ 2° Yaw

24% resolution at 10 GeV --> 75%/sqrt{E}

Now can match to GEANT predictions

~ 15% Quartz packing
Lead Absorber

CONCLUSIONS:

1) Further analysis of sampling resolution will determine the sampling frequency we will require, including sampling requirements for measurement of muon energy loss + EM shower leakage

2) Further analysis of e/pi will determine the sampling fraction which we will require

3) We have data in hand for muon signals and for the study of muon energy loss measurement

4) Our light yield is currently adequate for our physics goals, using existing rad-hard materials

5) Fiber-based forward calorimeter technologies have demonstrated promise in beam tests

Calibrated + Corrected results by Sept. 1, 1992

gem

γeμ

Presentation by:

F. E. Taylor

F. E. Taylor
8/5/92

STATUS OF GEM MUON SYSTEM

Issues:

- Decisions we face:

  (i) big wheel or separate sector?

  (ii) which technologies?
  - chambers and alignment scheme
  - trigger

  (iii) R&D plans for FY93
  - how to down scale?

- Problems with impact on design:

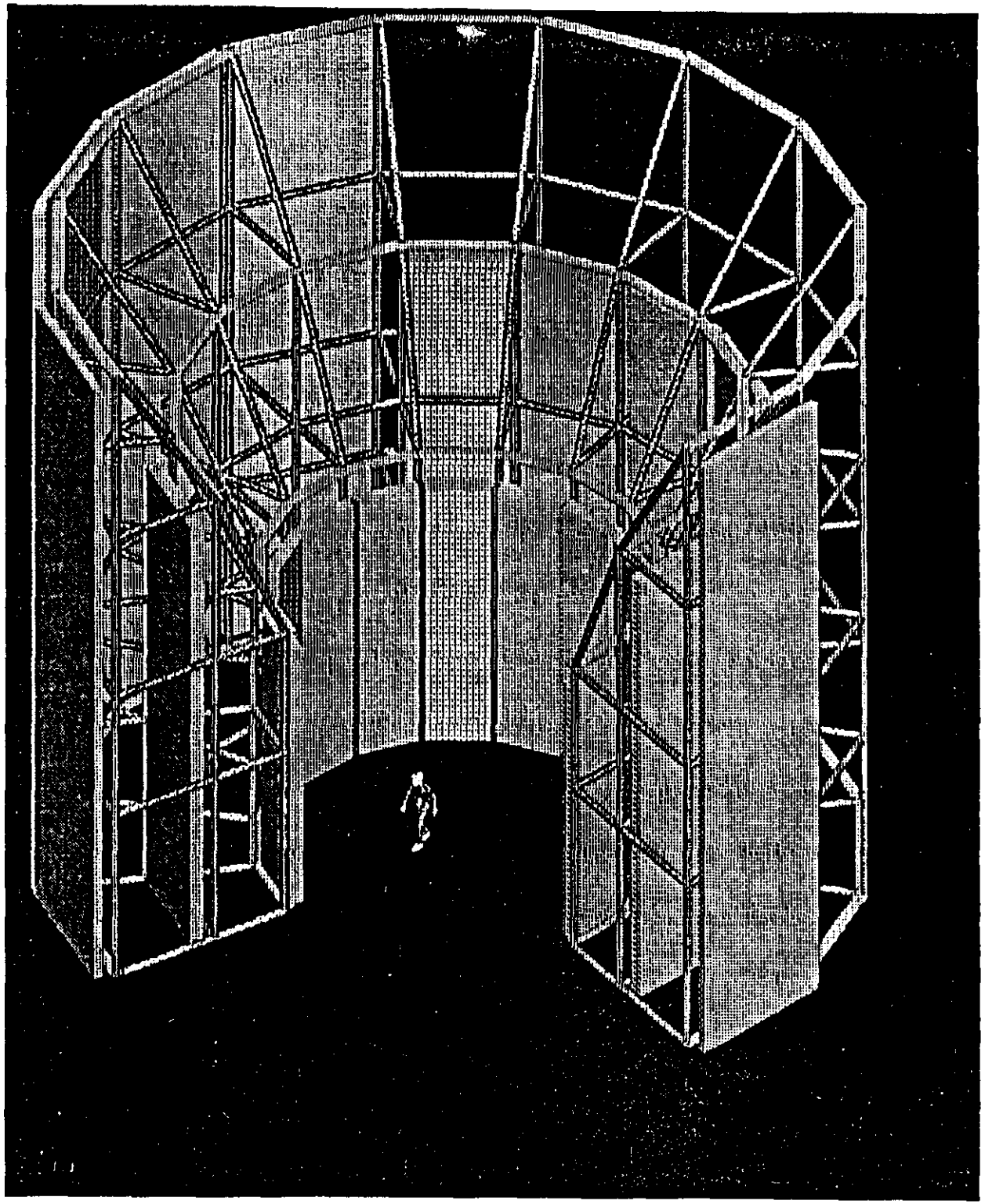
  (i) number of chambers in first SL

  (ii) neutron backgrounds, esp. in EC

- Woods Hole PAC:

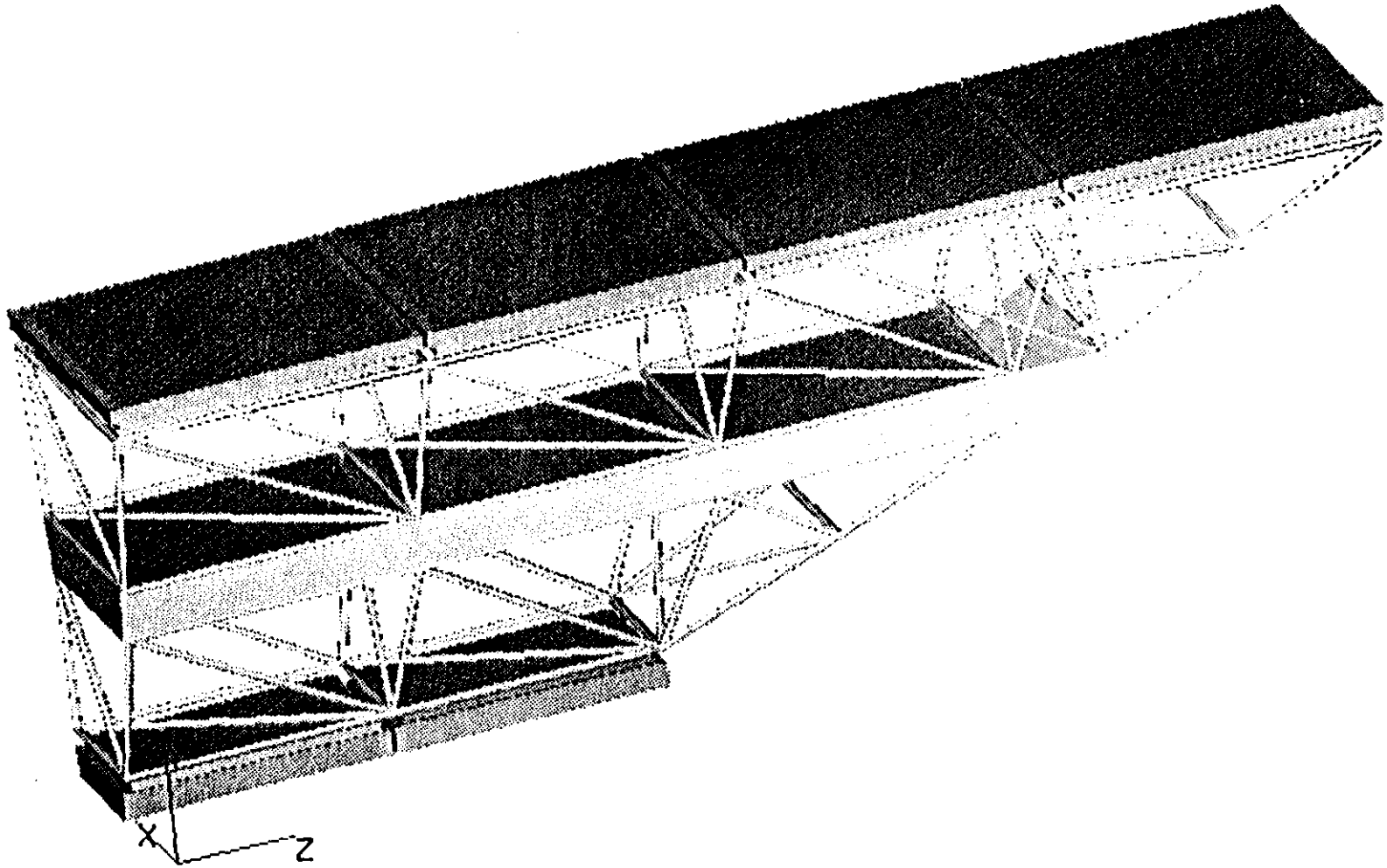
"Is the GEM muon system really *robust* ?"

"Big Wheel"
Pre-Assembled &
Aligned on
Surface
(Also for Ends)

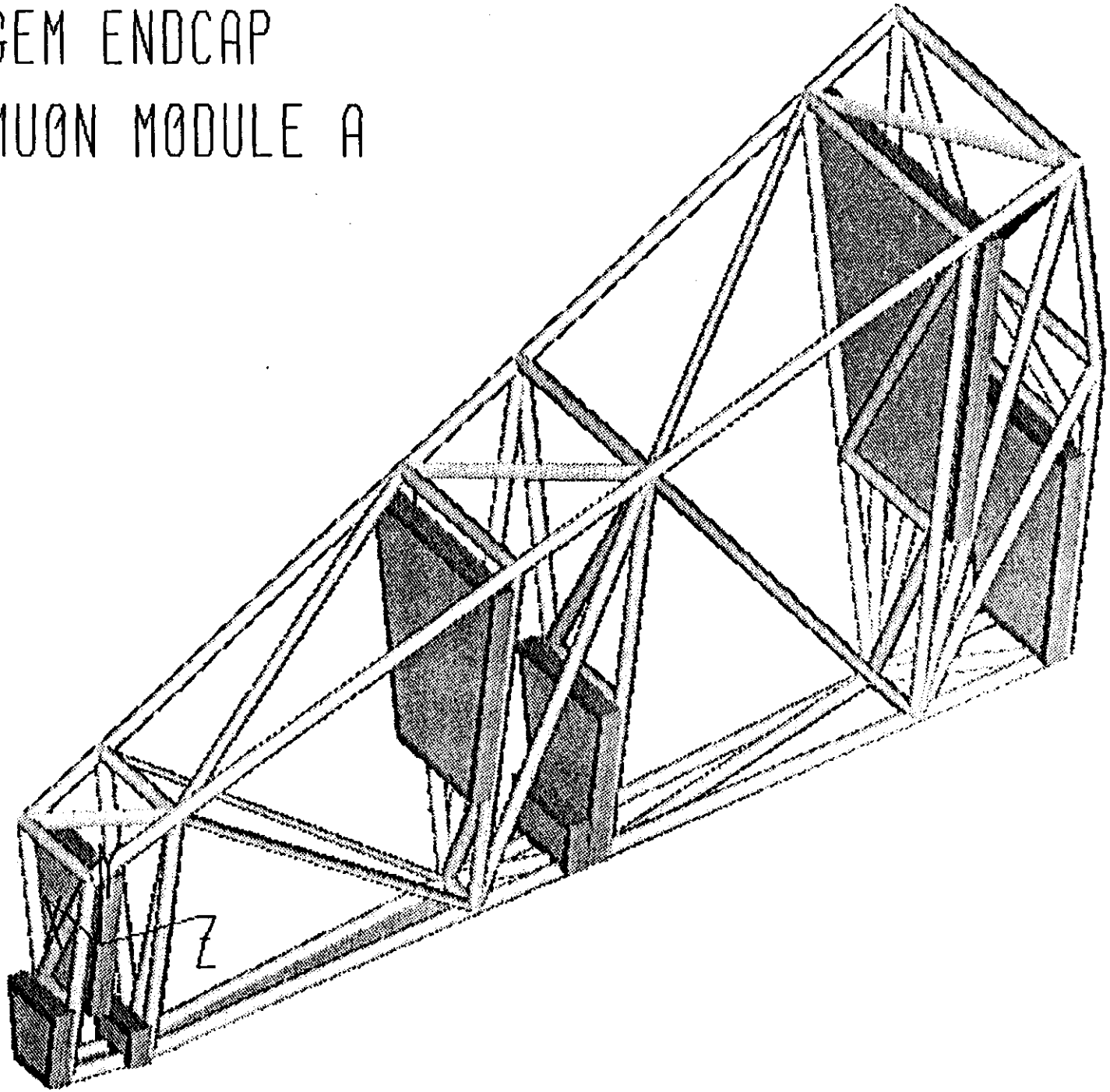


GEM BARREL REGION

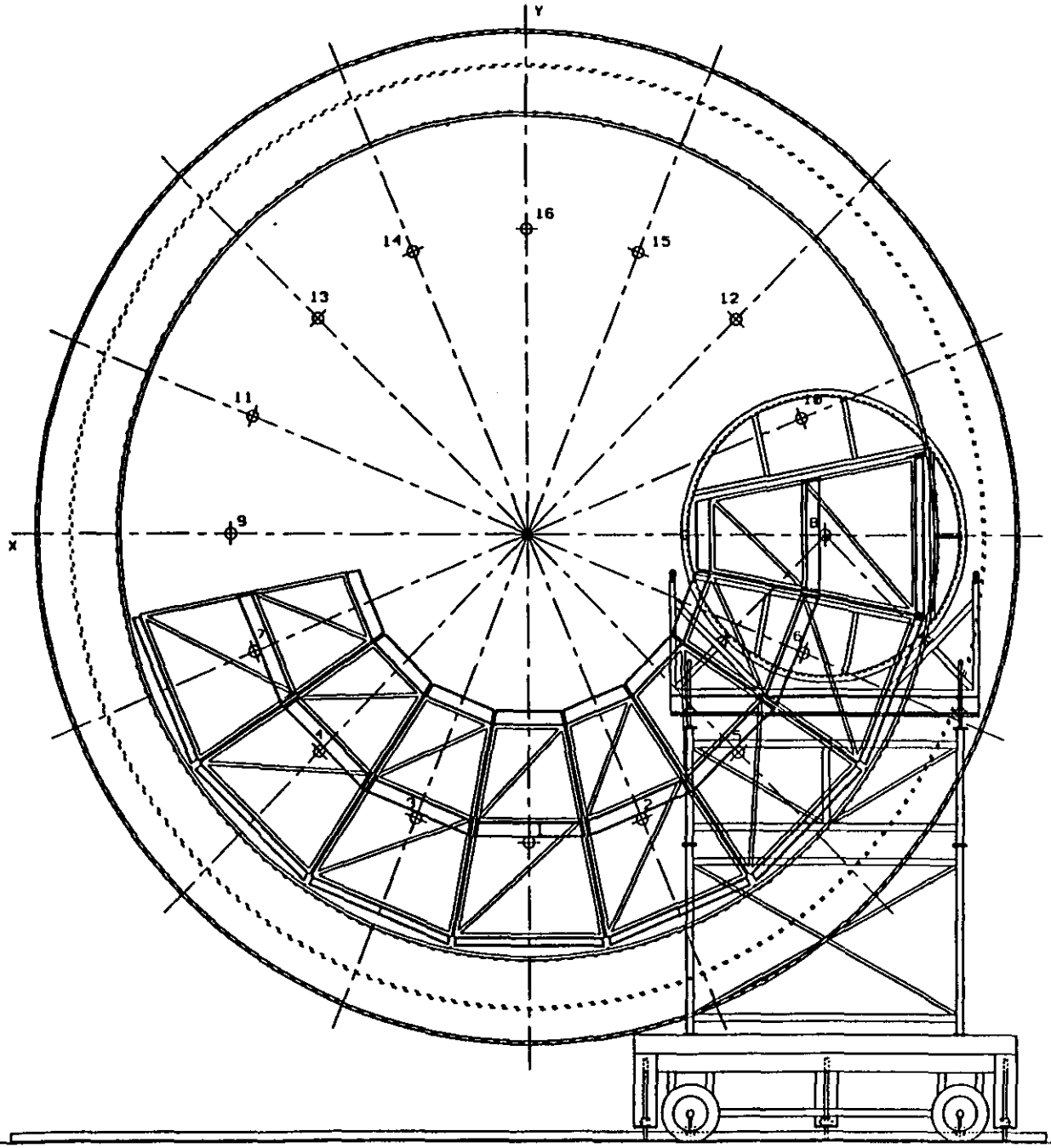
MUON MODULE



GEM ENDCAP
MUON MODULE A



BARREL REGION INSTALLATION
(3-O'CLOCK POSITION)



Schedule for Technology decision:

• present time	Construct full scale prototypes
• 8/15/91	Deliver chambers to TTR [Dubna PDT here, but all other full-scale prototype will not be at the TTR until 10/15/92]
• 8/20/92 - 9/15/92	Test chambers with cosmics
• 8 - 9/92	Test CSCs in RD5 beam at CERN
• 9/15/92 - 10/1/92	Evaluate tests and prepare report.
• 10/1/92	Written report from each technology to muon steering committee and external reviewers.
• 10/8/92	Rate technologies and pose "ultimate questions".
• 11/8/92	Final decision (reaffirm 10/8/92)
• 10/9/92 - 12/15/92	Develop chosen technologies for TDR

Recent Activities:

- Engineering:

  developed a set of criteria by which Bigwheel and Sector option of support structure will be judged. (Sawicki-LLNL and Nimblett-Draper)

  performed a first look at stresses of support structure in both sector and bigwheel concepts. (Furey-Draper and Gamble-SSCL)

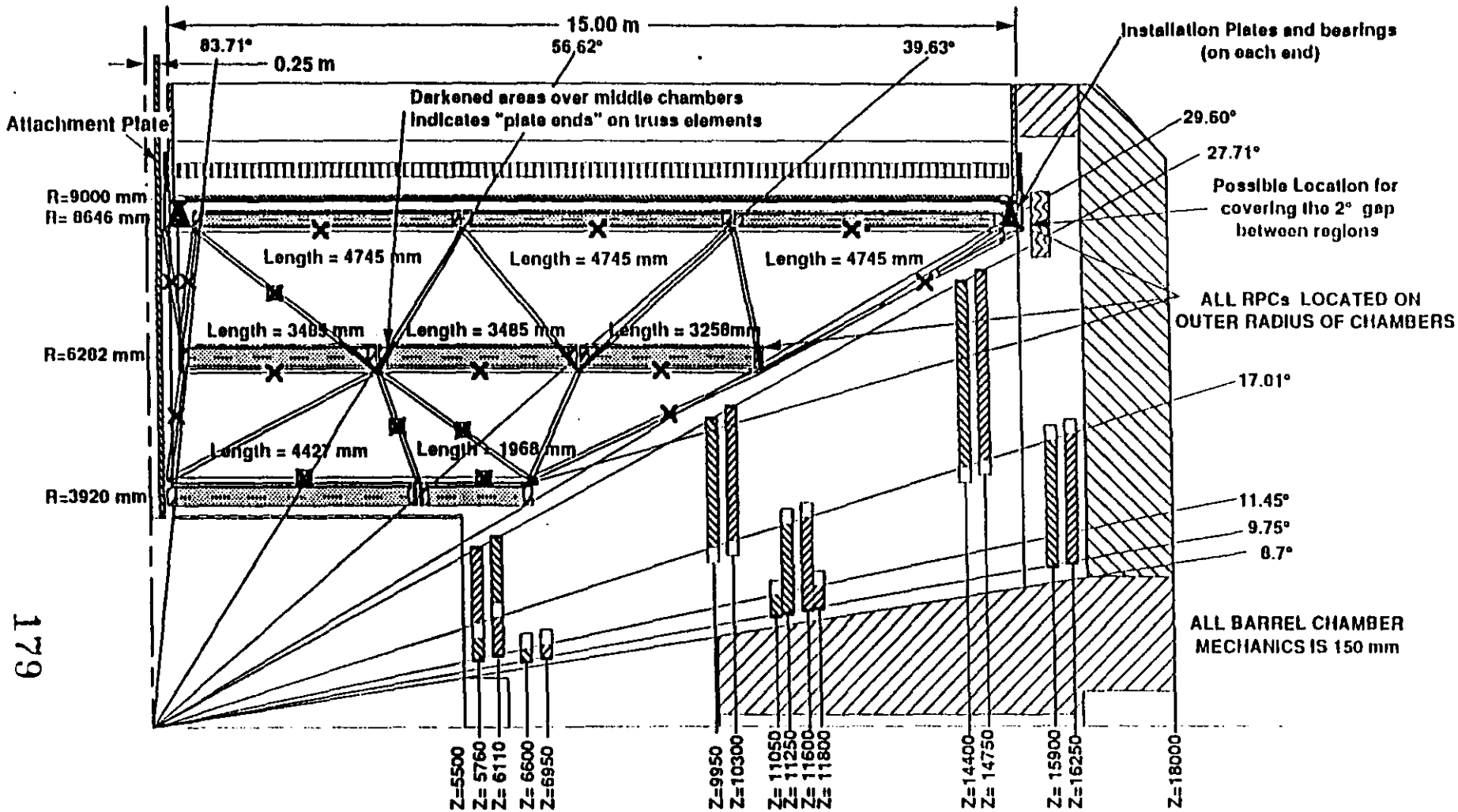
  designing truss structure for 2-3-3 configuration in barrel-Baseline 1.1. (Nimblett-Draper)

  investigated a new method of aligning muon chambers, resulting in softening requirements. (Mitselmakher-SSCL and Ostapchuk-SSCL)

  developed a layout of CSCs in barrel. Specified number of chambers, sizes, and channel counts.

Sector/Bigwheel evaluation schedule

August 12	Preliminary reports from all categories Identify remedial analysis and evaluation
August 19	Preliminary presentation of comparisons Identification of areas of diagreement
August 26	Final arguments
September 1	Final report and presentation

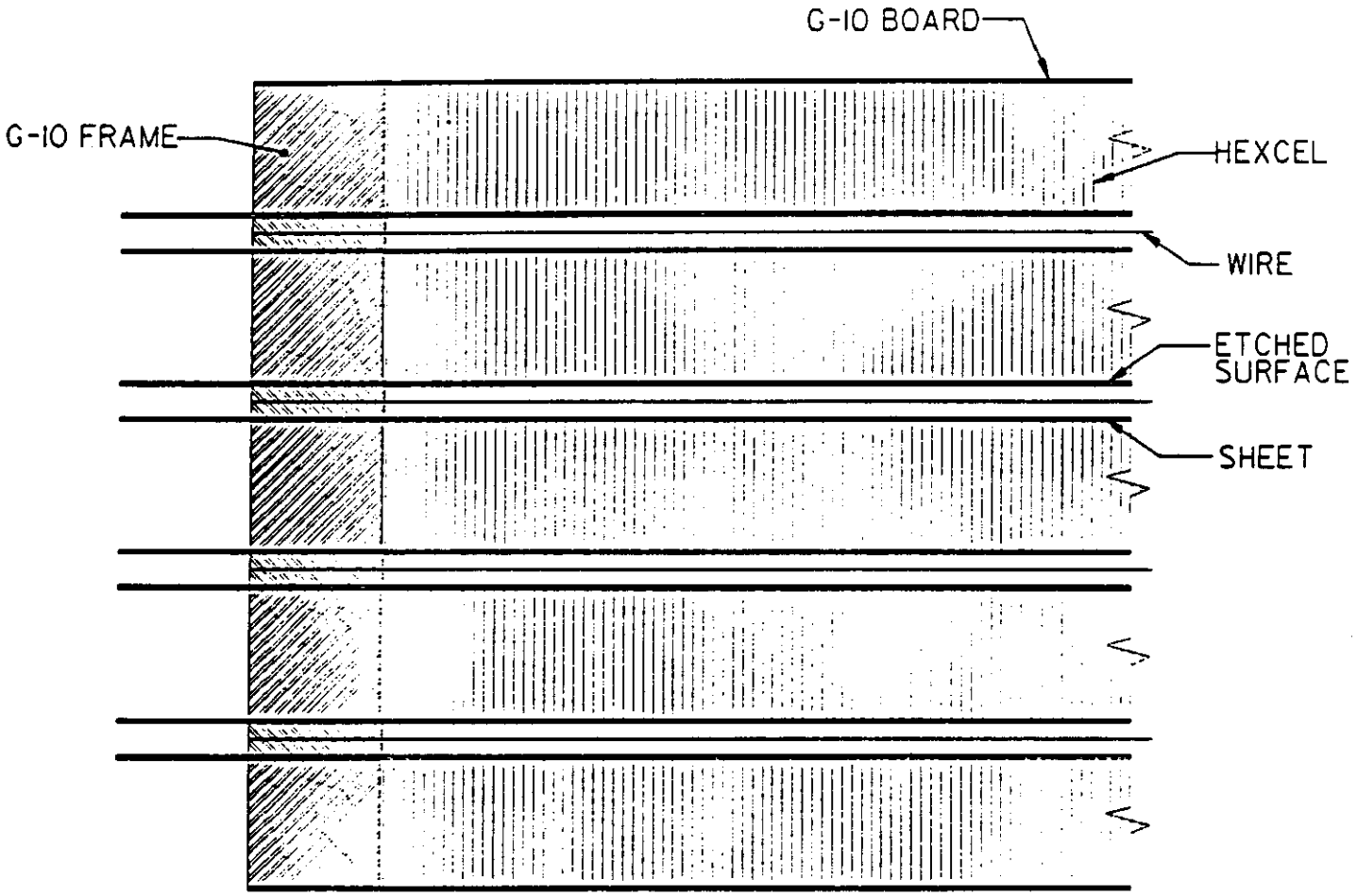


X----- Indicates Frame which has Crossed Bracing

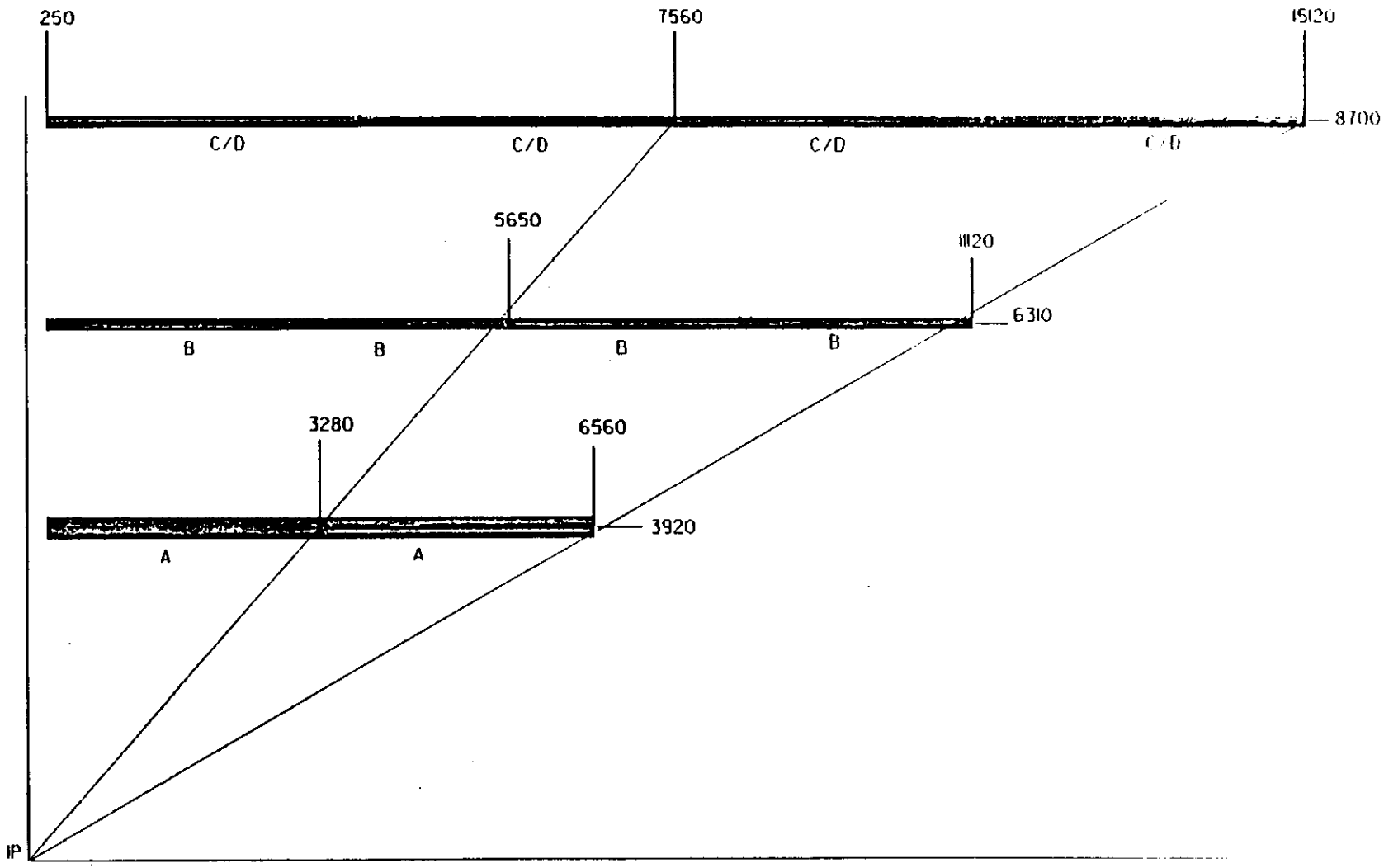
▣----- Indicates Frame which has Crossed Bracing and Mult. Scatt Concerns

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

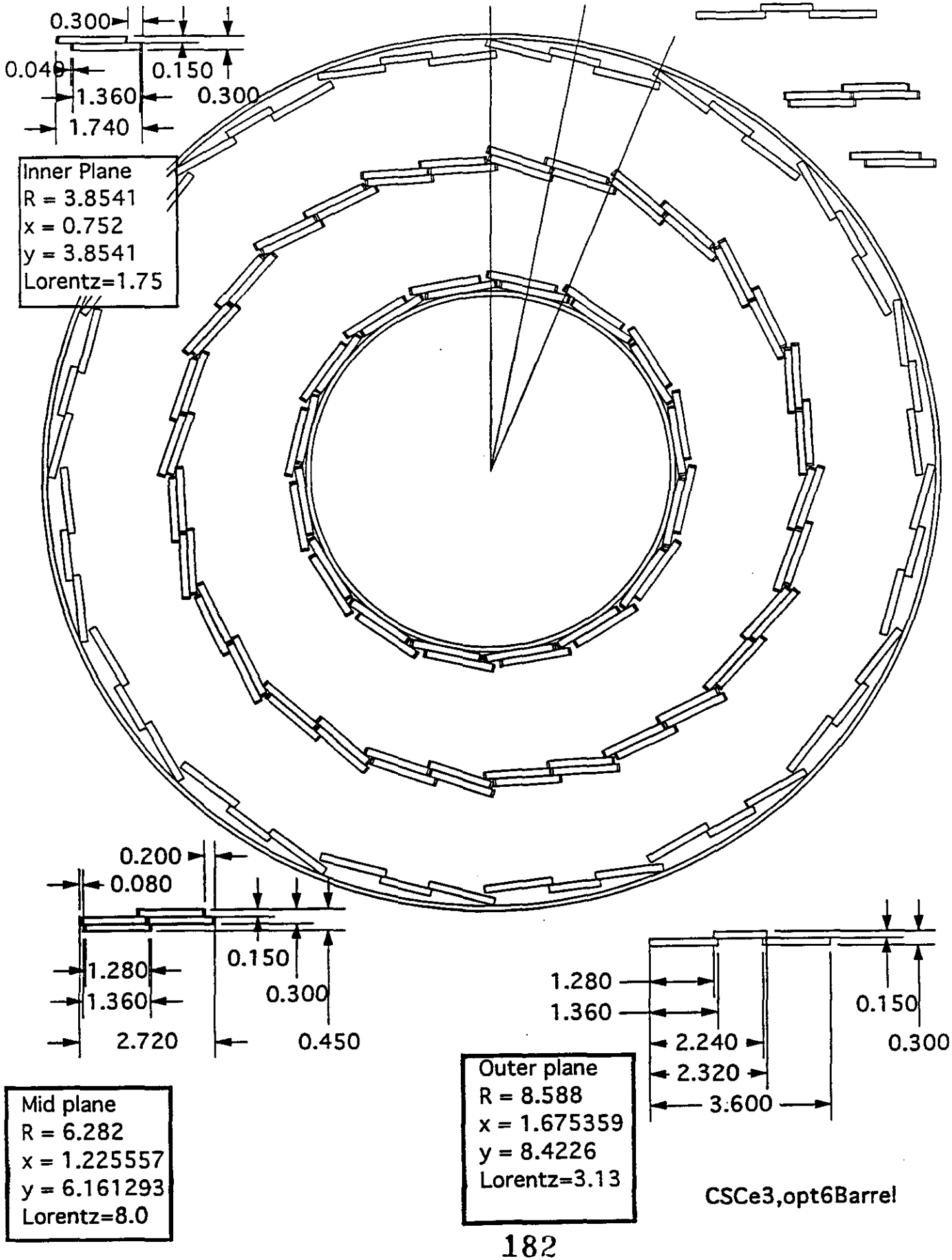
Fermi Laboratory	
GEM 2,3,3 PDT Projective Muon System	
Drawn By: F. Nimblett	Rev (-)
Dwg. No: GMU0016	7/17/92
Approved by: fen	



BARREL CSC MODULE CROSS SECTION



BARREL CSC CHAMBERS - SIDE VIEW


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
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
0.300
2.320
3.600
Outer plane
R = 8.588
x = 1.675359
y = 8.4226
Lorentz=3.13
CSCe3,opt6Barrel

Sizes and features of Barrel CSC modules

Four sizes

A Chambers	1440x3250 mm
B Chambers	1280x2700 mm
C Chambers	1280x3750 mm
D Chambers	960x3750 mm

Superlayer	Type of Chamber	No of Chambers /wheel.sector for 8/4/4 (Total for muon system)	No of Chambers /wheel.sector for 8/8/4 (Total for muon system)
SL 1	A	4 (128)	4 (128)
SL2	B	8 (256)	16 (512)
SL3	C	8 (256)	8 (256)
SL3	D	4 (128)	4 (128)
Total Modules		768	1024
Total Cathode Channels		780K	1030K

- Chamber technologies:

  constructed and shipped to TTR a full scale PDT chamber: 1 m x 4 m x 8 layers from Dubna. (Golutvin-Dubna et al.)

  setting up tests of CSCs in RD5 beam at CERN. Two 0.6 m x 0.6 m chamber constructed and ready to be shipped to Geneva and Dallas.

  constructed and tested a 0.5 m x 4 m LSDT prototype. A 1 m x 4 m chamber under construction.

  various PDTs, CSCs, RPCs under construction.

Status:

not all technologies will have full scale prototypes to test before the 10/8/92 deadline. Final decision requires that full scale prototypes be tested.

Needed:

more engineering help for CSCs. Details of attachment to support structure has to be worked out. Optimization of number of sectors must be done.

- Simulations:

  simulated the performance with energetic muons for LSDT option. Working on simulation of background for CSC case.

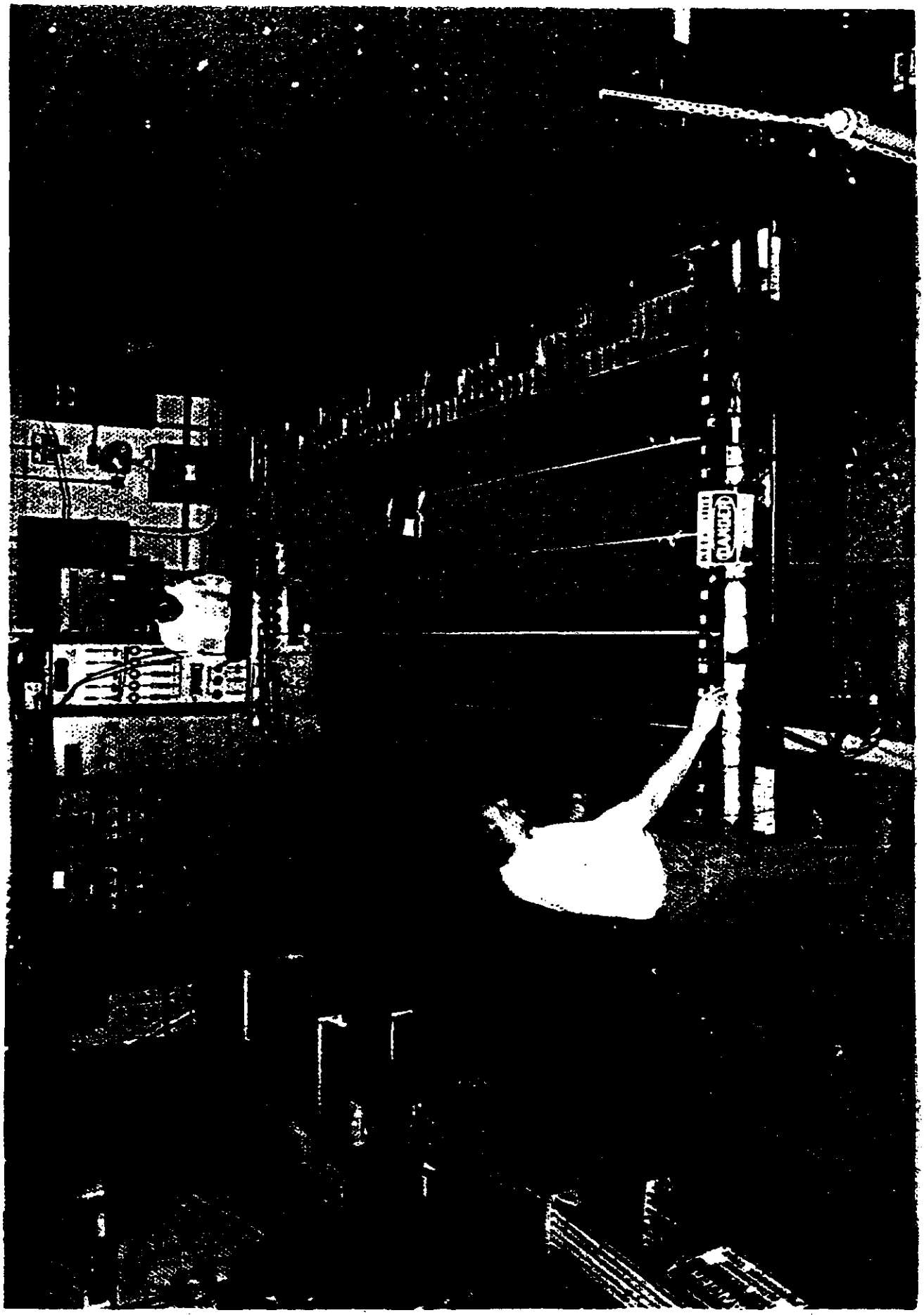
  appointed a "Neutron Committee" (Osborne, Whitaker, Atiya, Waters). Evaluate information on neutron backgrounds and direct tests and simulations.

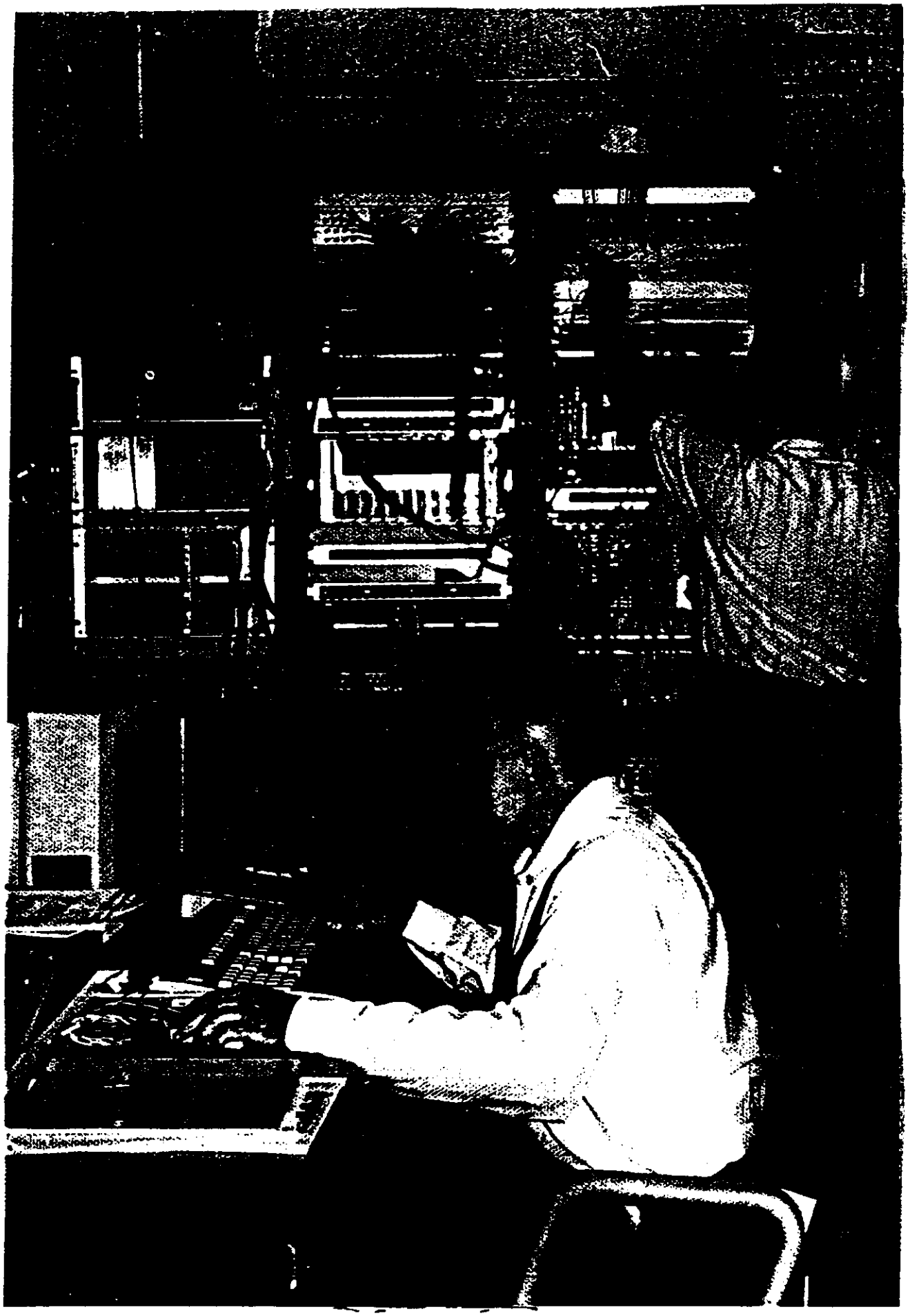
- Needed:

  results from hit-level Monte Carlo of each technology for associated debris of muon track, neutron backgrounds, etc.

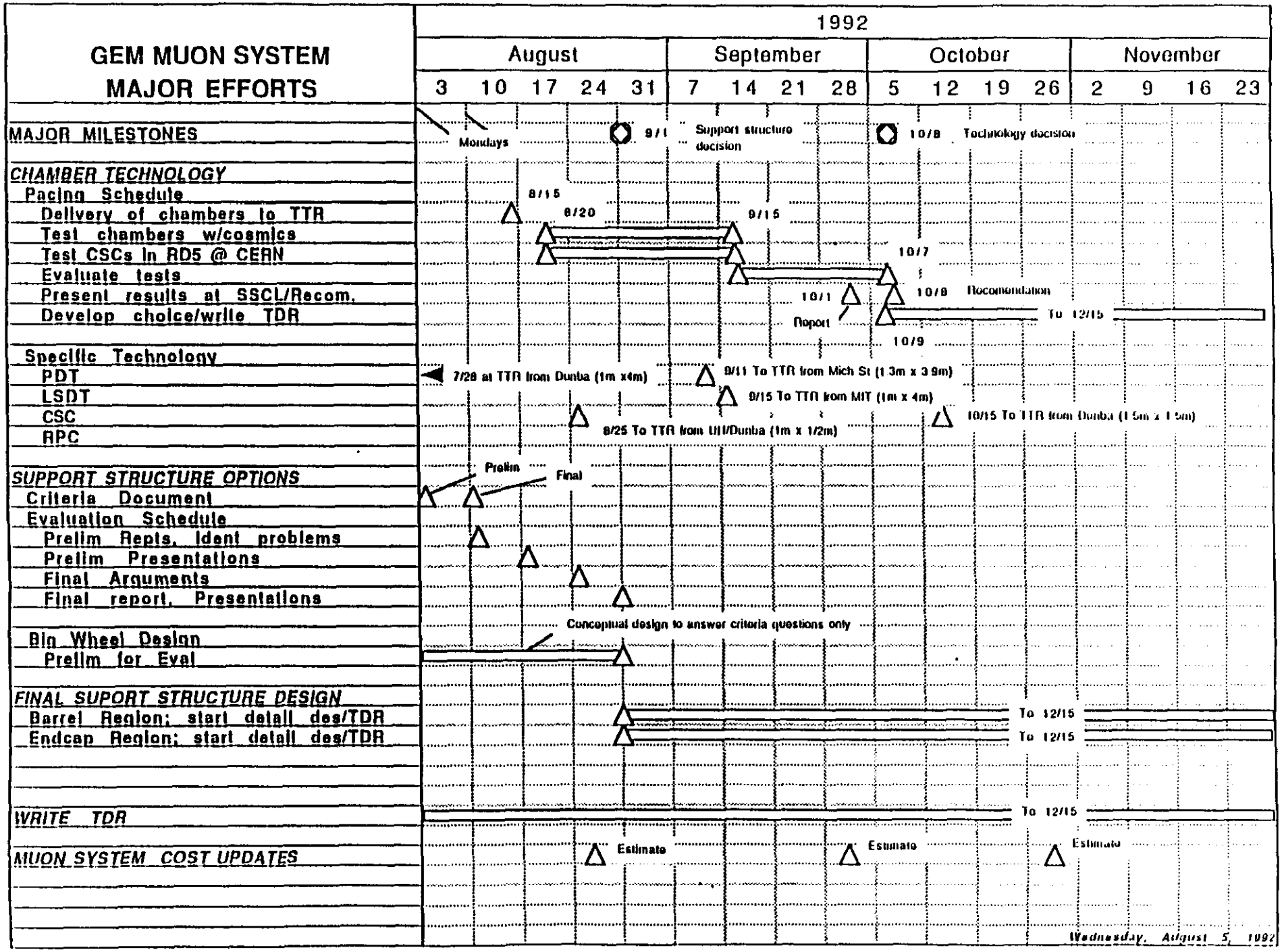
  more simulations of neutron background and perhaps more measurements. Present fluences are uncomfortably high in EC.

EAST


DANGER



GEM MUON SYSTEM NEAR TERM SCHEDULE



gem

γeμ

Presentation by:

G. Mills

G. Mills

GEM Trigger / DAQ

Council Meeting

8/5/92

Geoff Mills

Si-Tracker Electronics Development Status
7-28-92

Bipolar

Two additional topologies were developed and being evaluated. (issues; bias stability and time-walk)

Two new SPICE libraries obtained from AT&T, simulations started. (CBIC-U2, V series)

Bid package for semi-custom ASIC(tile array-based, single channel) being prepared to place an order before October 92

CMOS

Architectural studies continues.

SPICE simulation of the main function blocks started using UTMC.

LSI rad-hard 0.7u process under evaluation.

Conversion of the UTMC HSPICE library to PSPICE started.

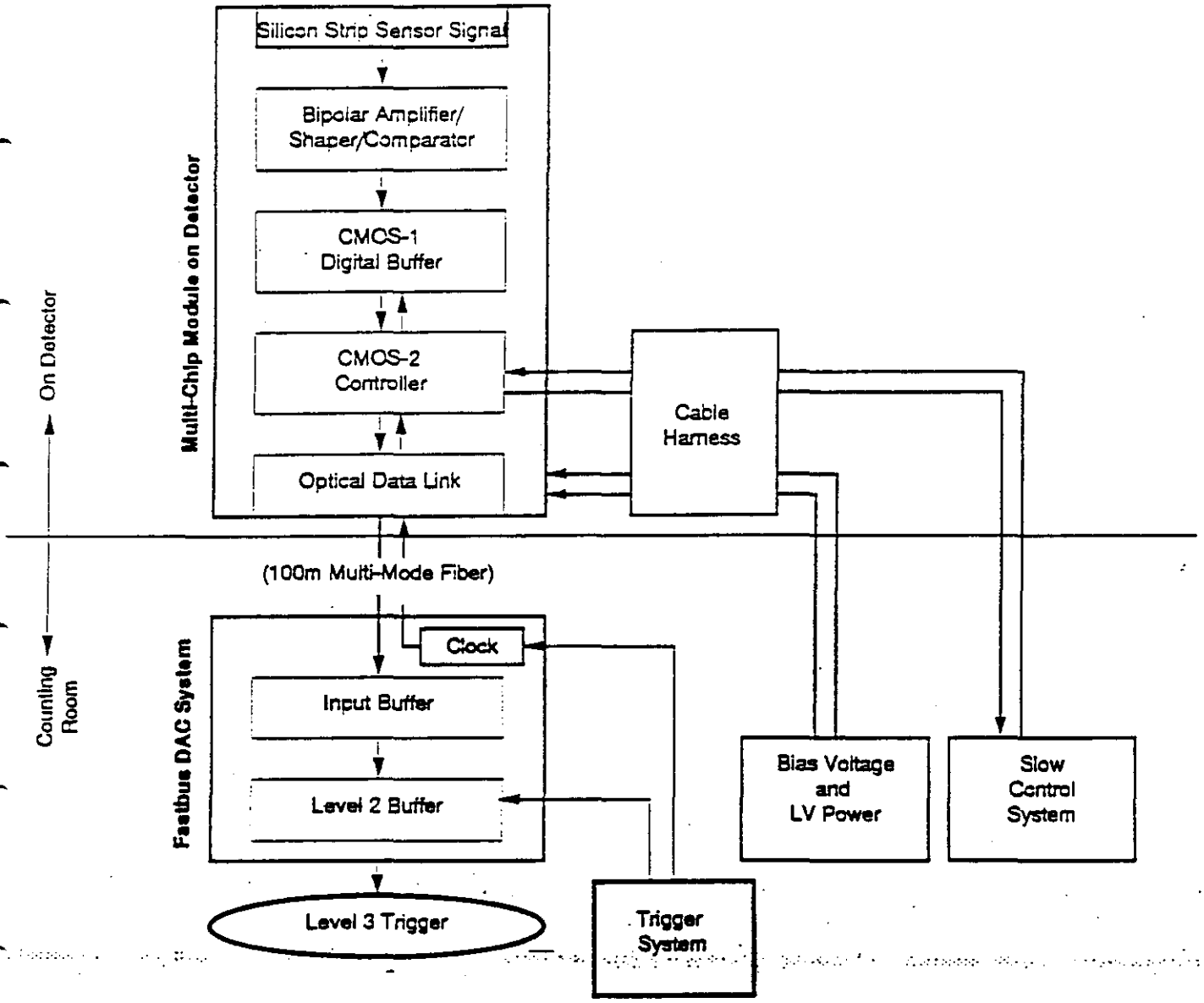
Fiber Optics

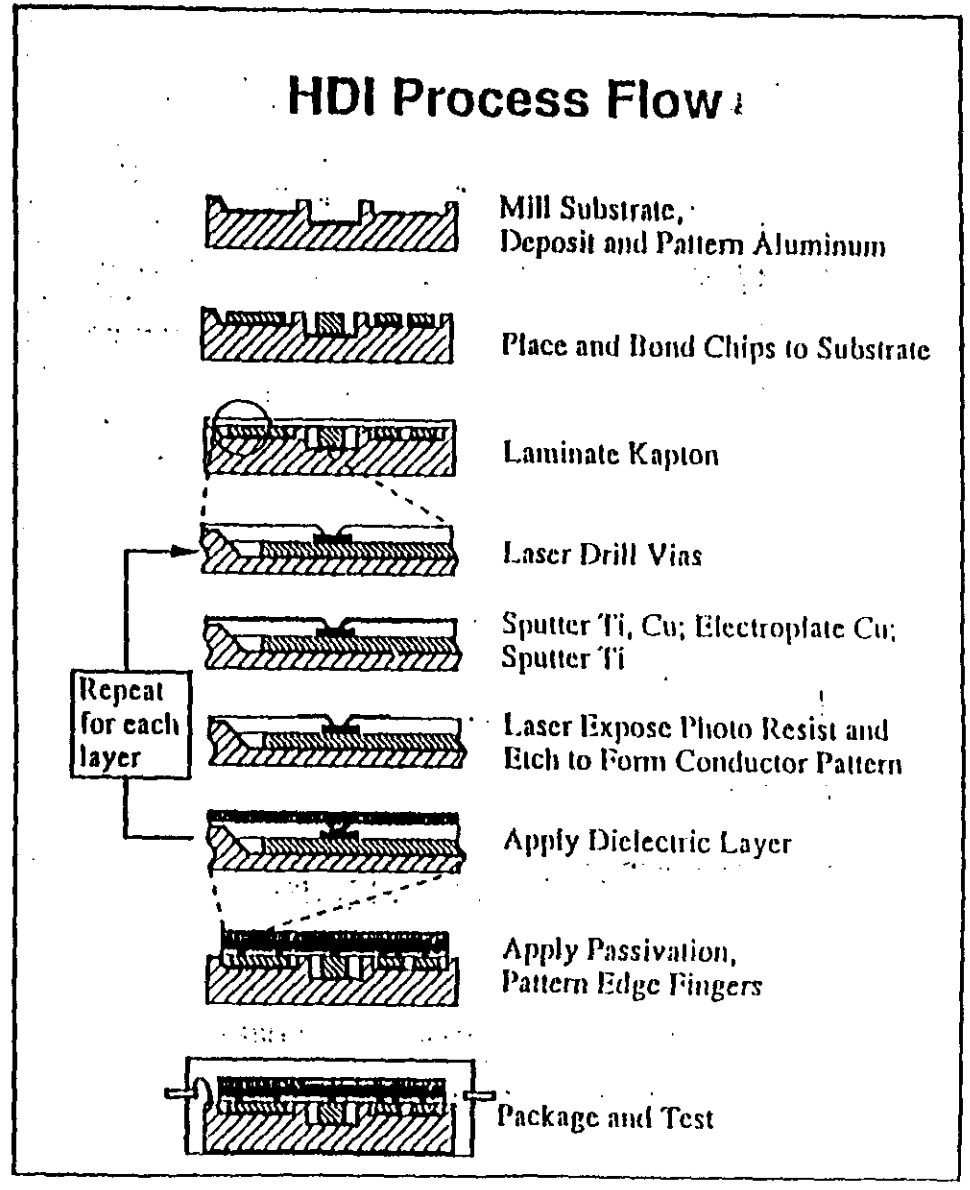
Purchased low-cost, rad-hard optical fibers for evaluation.

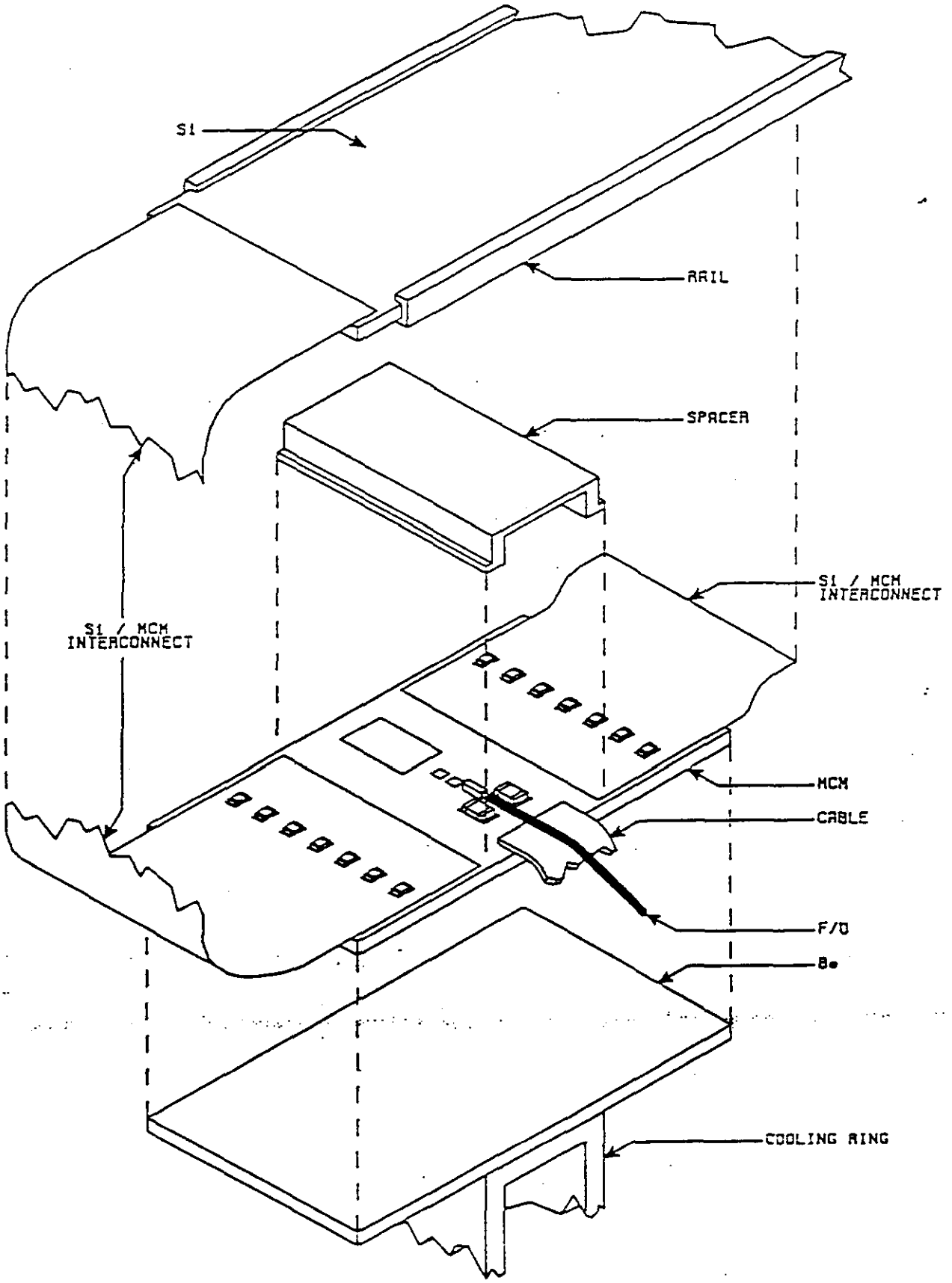
MCM

A realistic layout of the MCM using TI/HDI process completed.
A new connection scheme between MCM and the strip detector studied.

Silicon Tracker Electronics System Architecture




HDI Process Flow
Mill Substrate,
Deposit and Pattern Aluminum
Place and Bond Chips to Substrate
Laminate Kapton
Laser Drill Vias
Sputter Ti, Cu; Electroplate Cu;
Sputter Ti
Repeat
for each
layer
Laser Expose Photo Resist and
Etch to Form Conductor Pattern
Apply Dielectric Layer
Apply Passivation,
Pattern Edge Fingers
Package and Test



GEM SILICON TRACKER. DETECTOR ASSEMBLY W/SPACER

NOT TO SCALE.

B.C. / C.R. / M.J.K. 4/28/92. DRAWN: M.J.K. 7/9/92.

LOS ALAMOS NATIONAL LABORATORY.SST-11.MCDL TEAM.MS0448.PO BOX 1663.LOS ALAMOS NM 87544. FILED FROM: GEMSST11_7.

Jim Musser

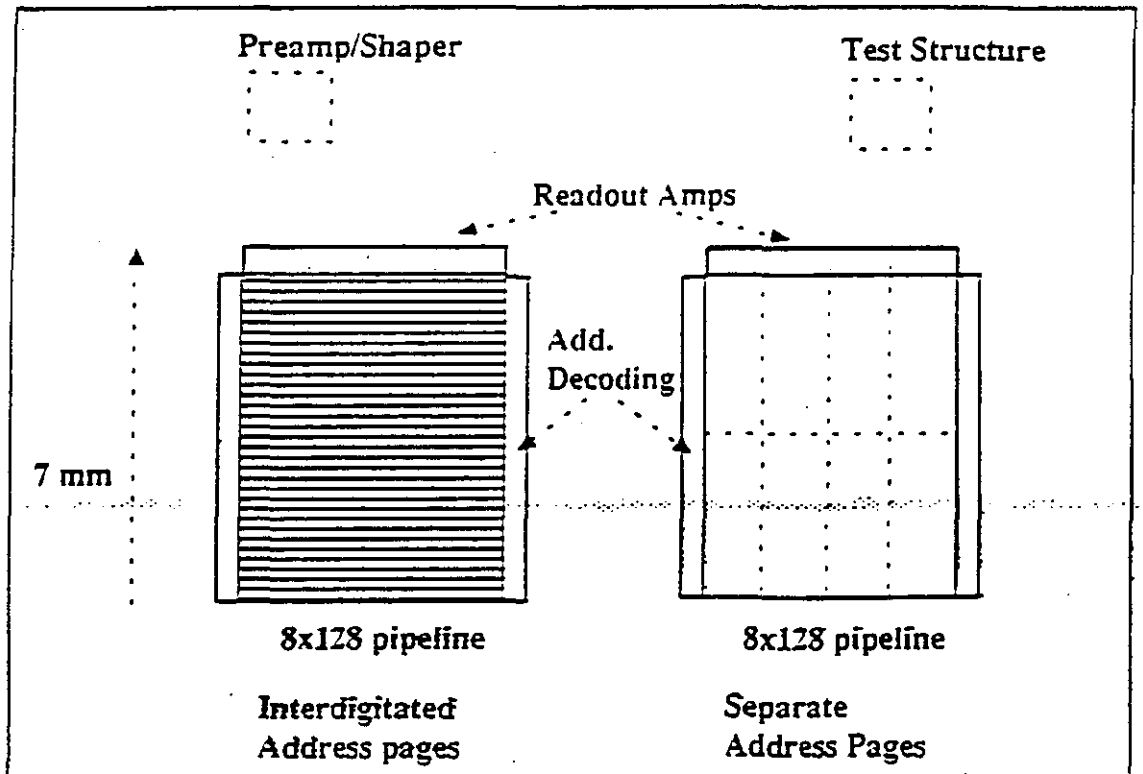
Central Tracker Status

Analog Pipeline Prototype

8 channel, 128 deep rad-hard SCA now in final stages of layout by ORNL in Harris AVLSI-RA process.

Design review at Harris in mid-September.

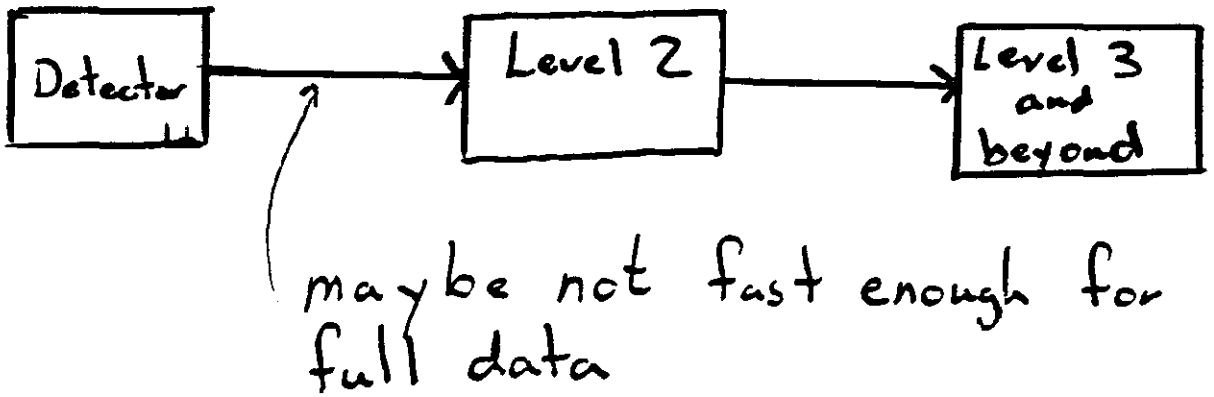
Fab run start - mid October



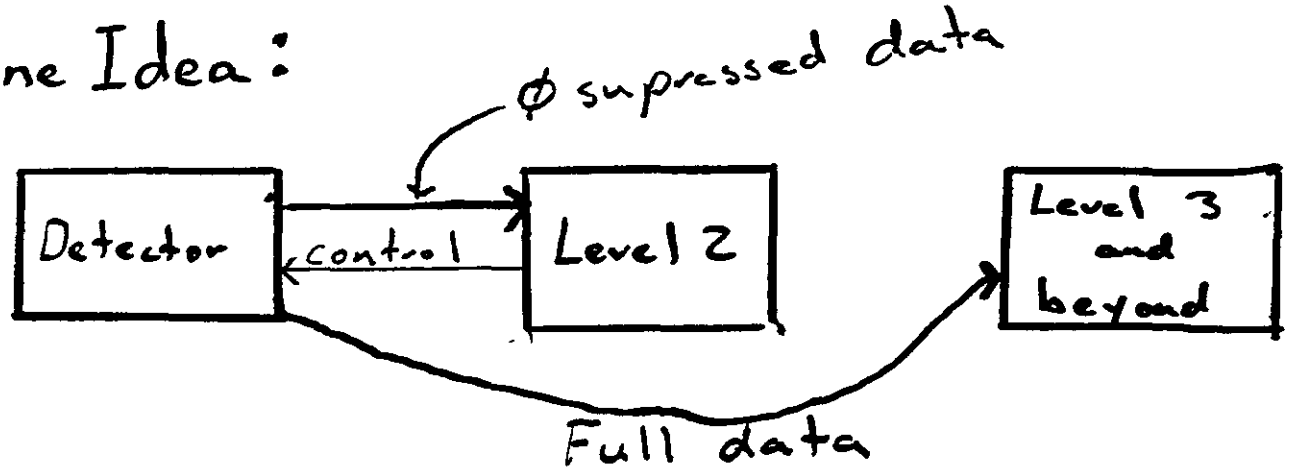
Each test chip contains two readout amp types and two readout topologies (voltage write voltage read / voltage write charge read)

Motivation for Zero Supression

Eric Prebys



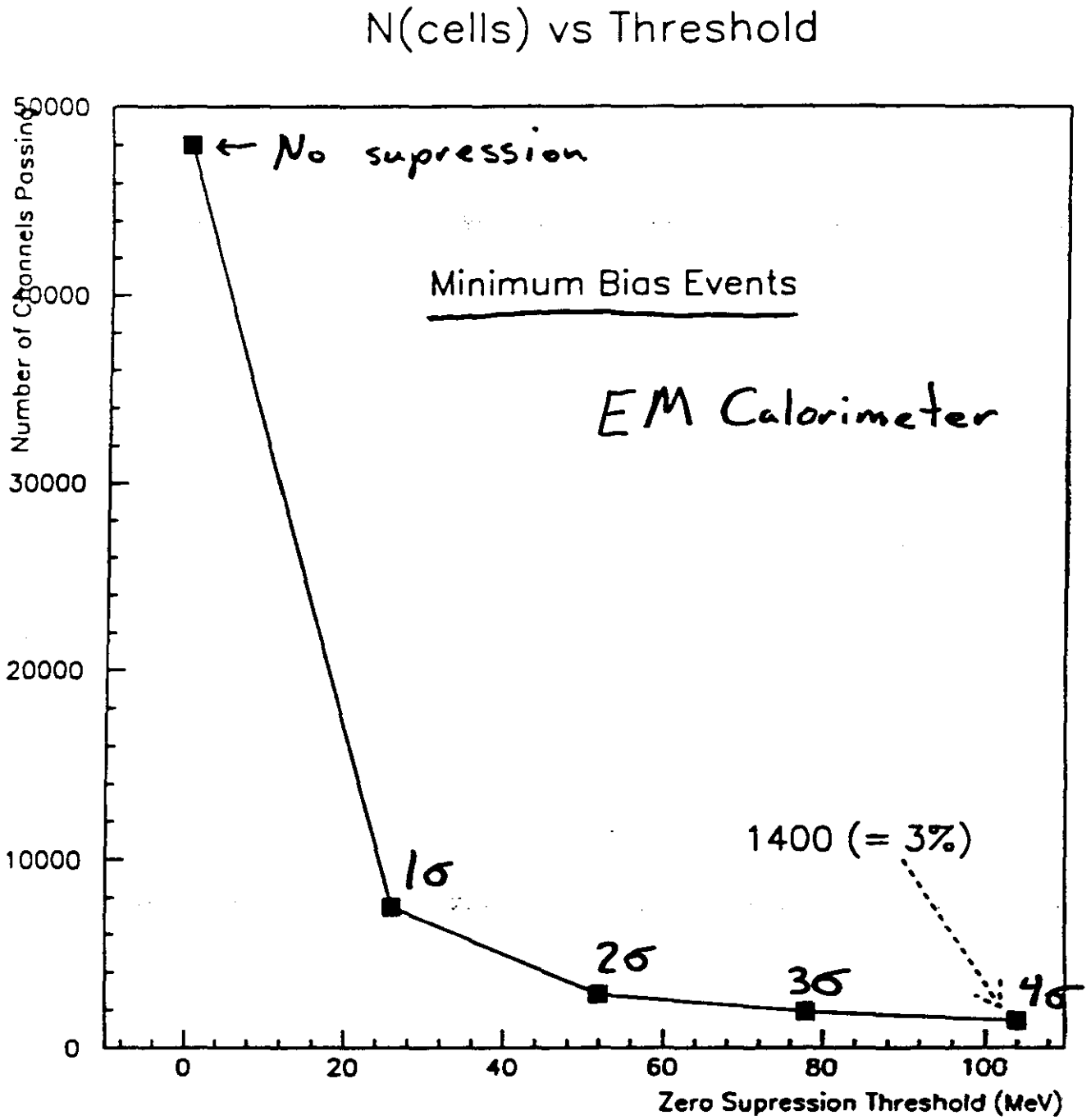
One Idea:



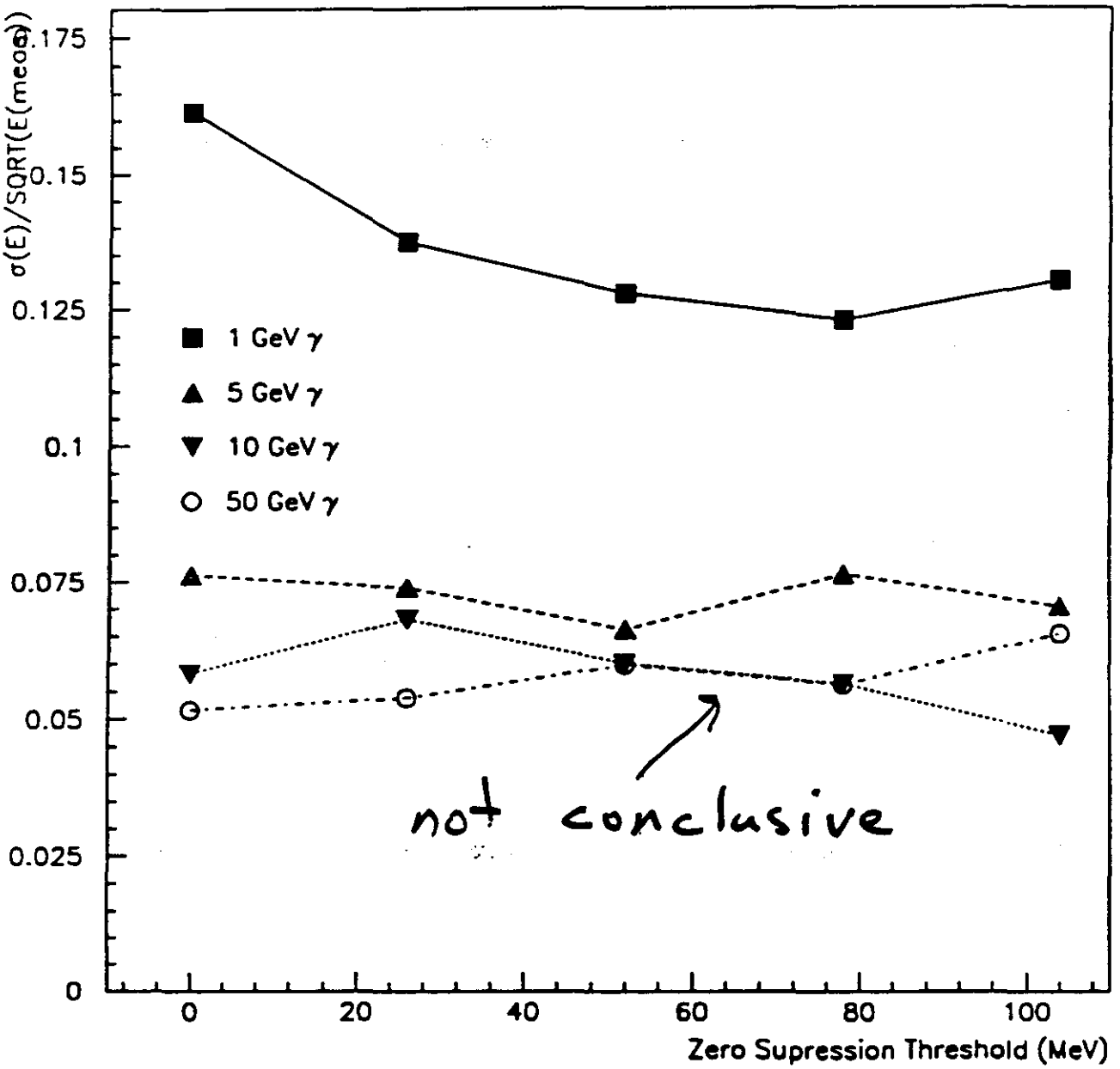
Possible, but two data paths unattractive

Can analysis live with zero-supressed data?

The Payoff:


N(cells) vs Threshold
Number of Channels Passing
50000
40000
30000
20000
10000
0
0
20
40
60
80
100
Zero Supression Threshold (MeV)
← No supression
Minimum Bias Events
EM Calorimeter
1σ
2σ
3σ
4σ
1400 (= 3%)

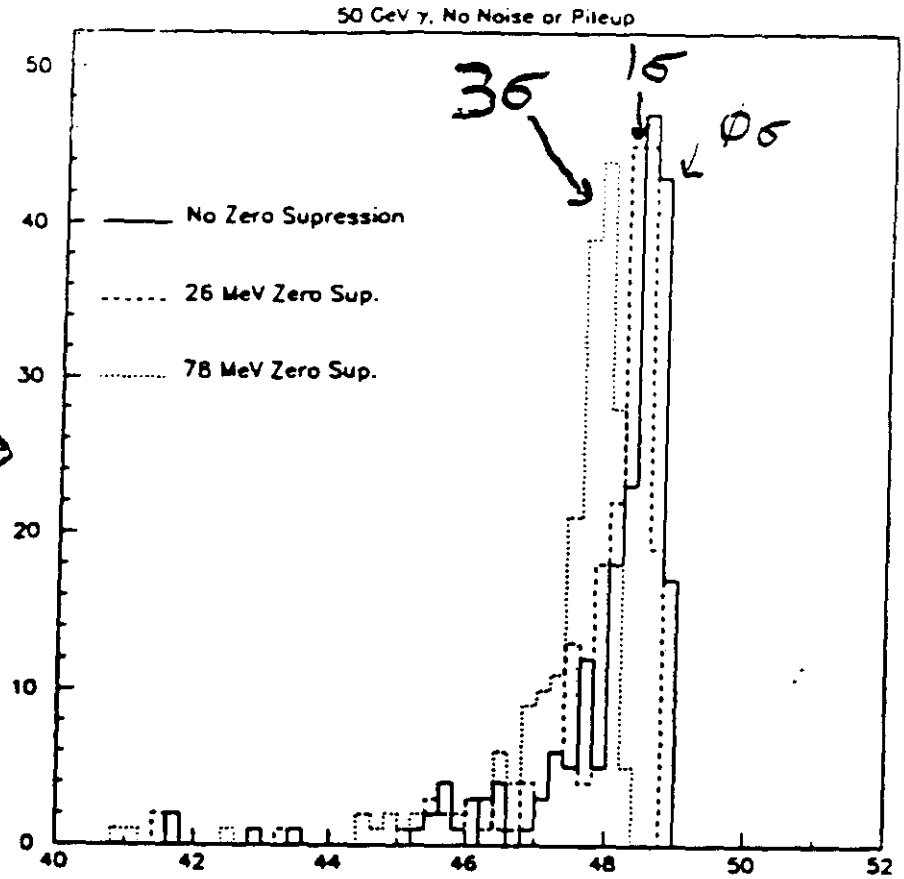
σ(E)/SQRT(E(meas)) vs. Threshold



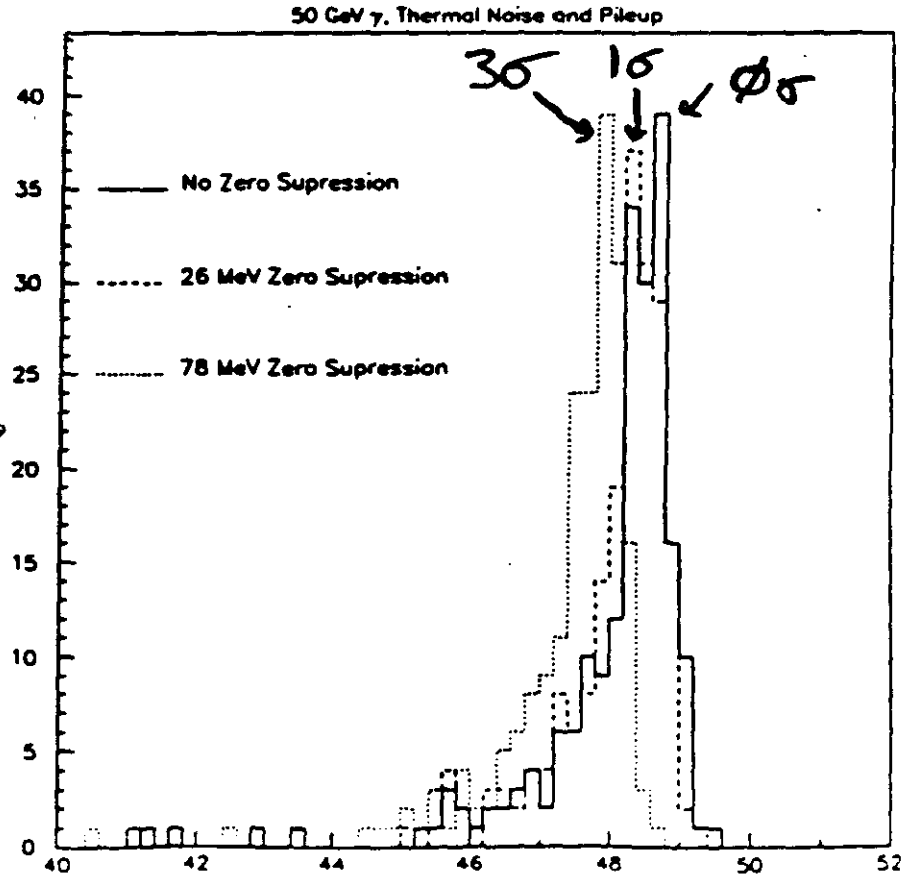
Response...

50 GeV γ

No Noise or Pileup →



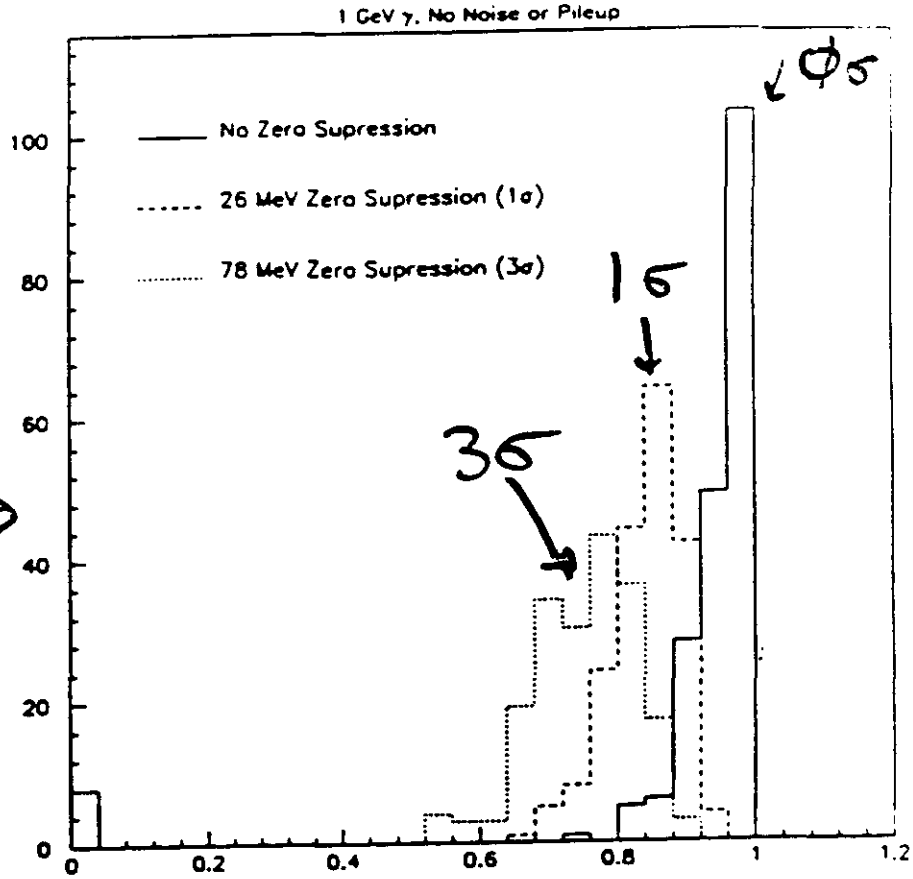
with Noise and Pileup →



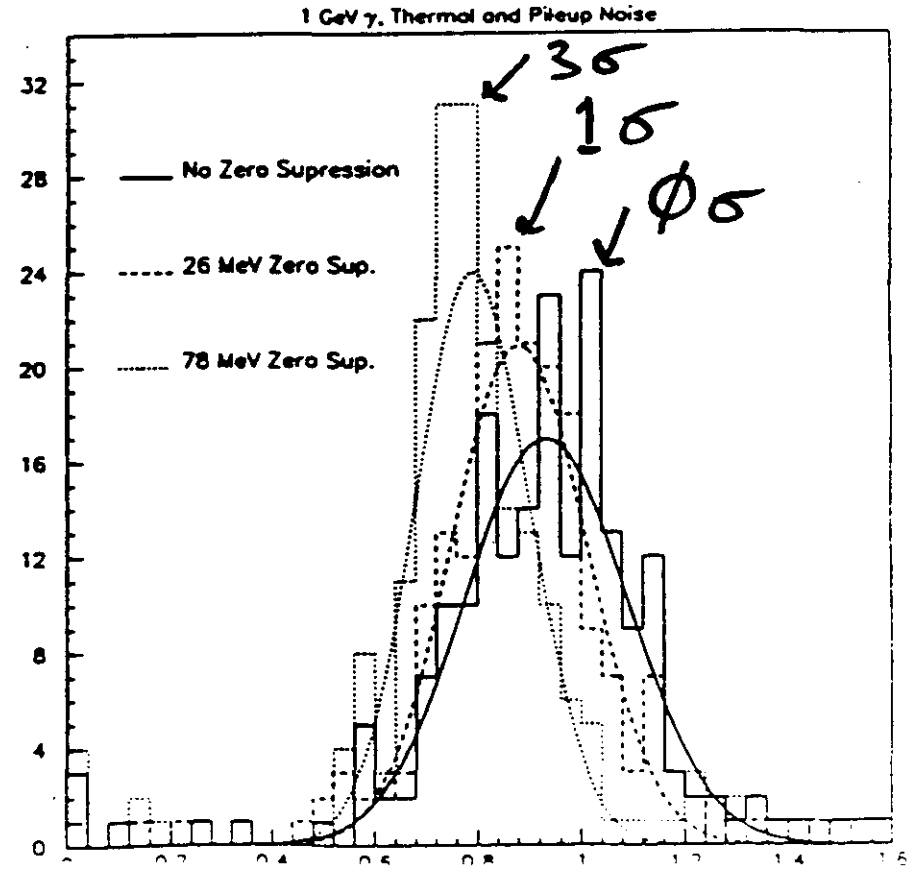
compare...

1 GeV γ

No Noise
or
Pile up →



with Noise
and
Pile up →



Ø sup. better!

Conclusions:

- Zero-supression would (of course) greatly reduce the number of channels read out.

- Effects on resolution probably tolerable.

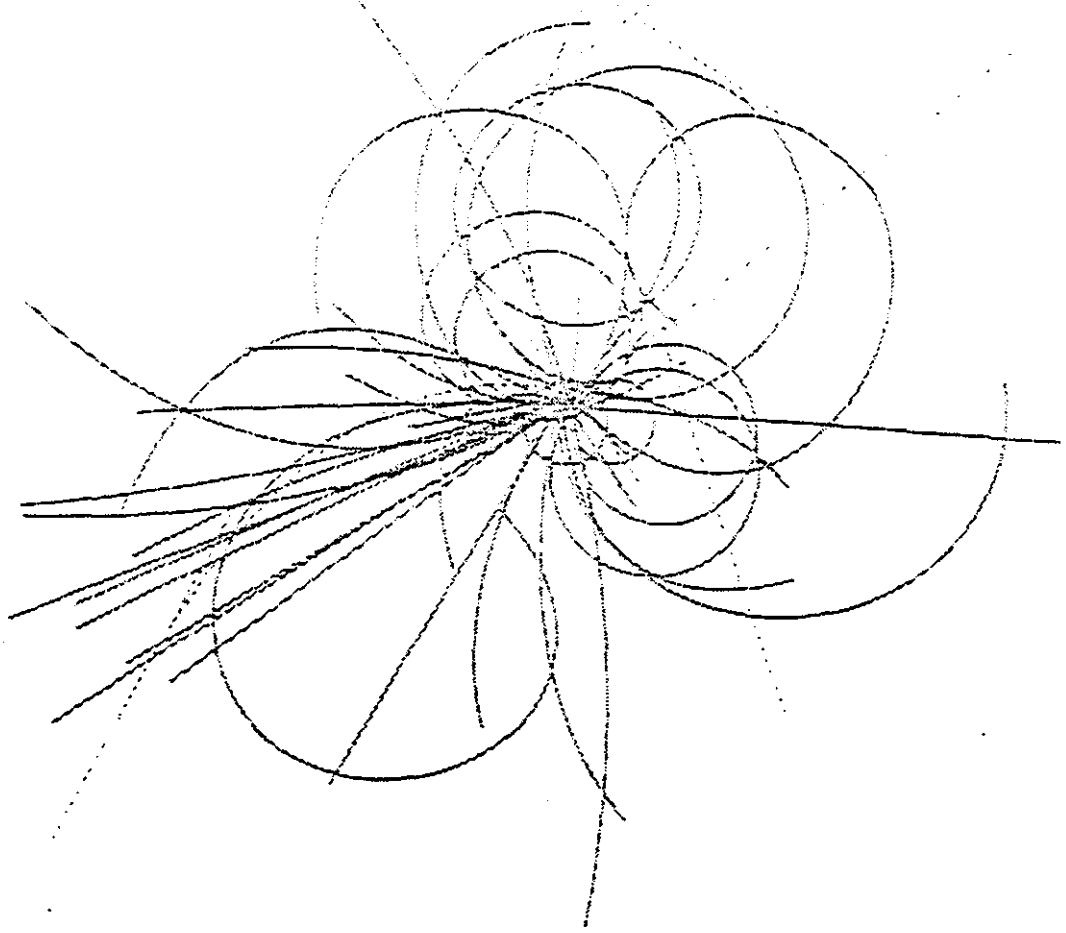
- Significant non-linearities introduced. Might affect multi-photon processes (π^0, etc.)

- Needs a bit more study.

- Maybe consider more complicated zero supression algorithms

SSCL-576

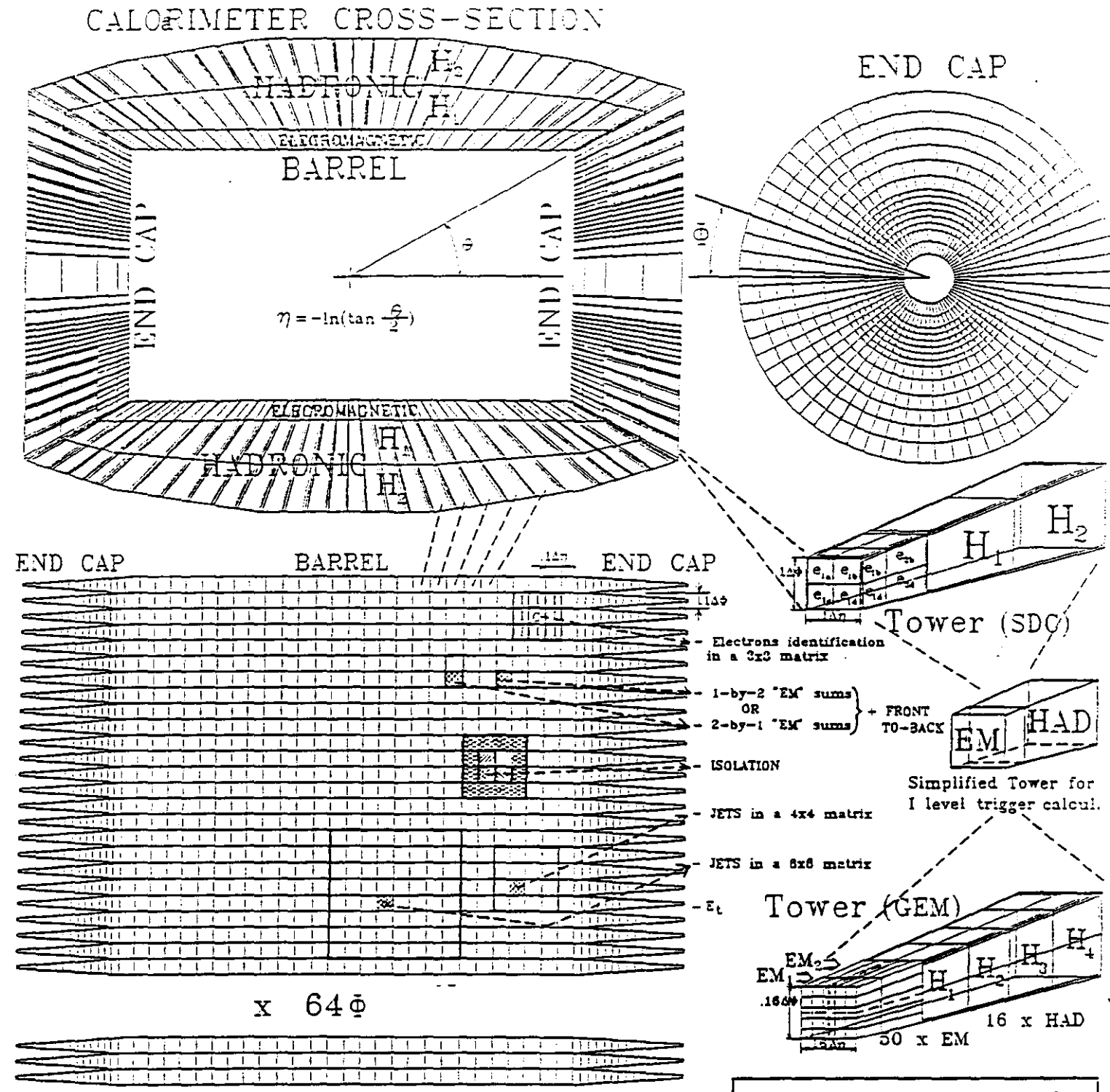
Superconducting Super Collider Laboratory



Fully pipelined and programmable I level trigger

D. Crosetto and L. Love

July 1992



Unrolled "Barrel" + unfolded END CAP = Towers processor array

ONE TOWER = ONE PROCESSOR

I level trigger granularity examples		
Experiment	$\Delta\eta$ $\Delta\Phi$	Number of processors
GEM	.16 x .16	1250
SDC	.1 x .1	3584

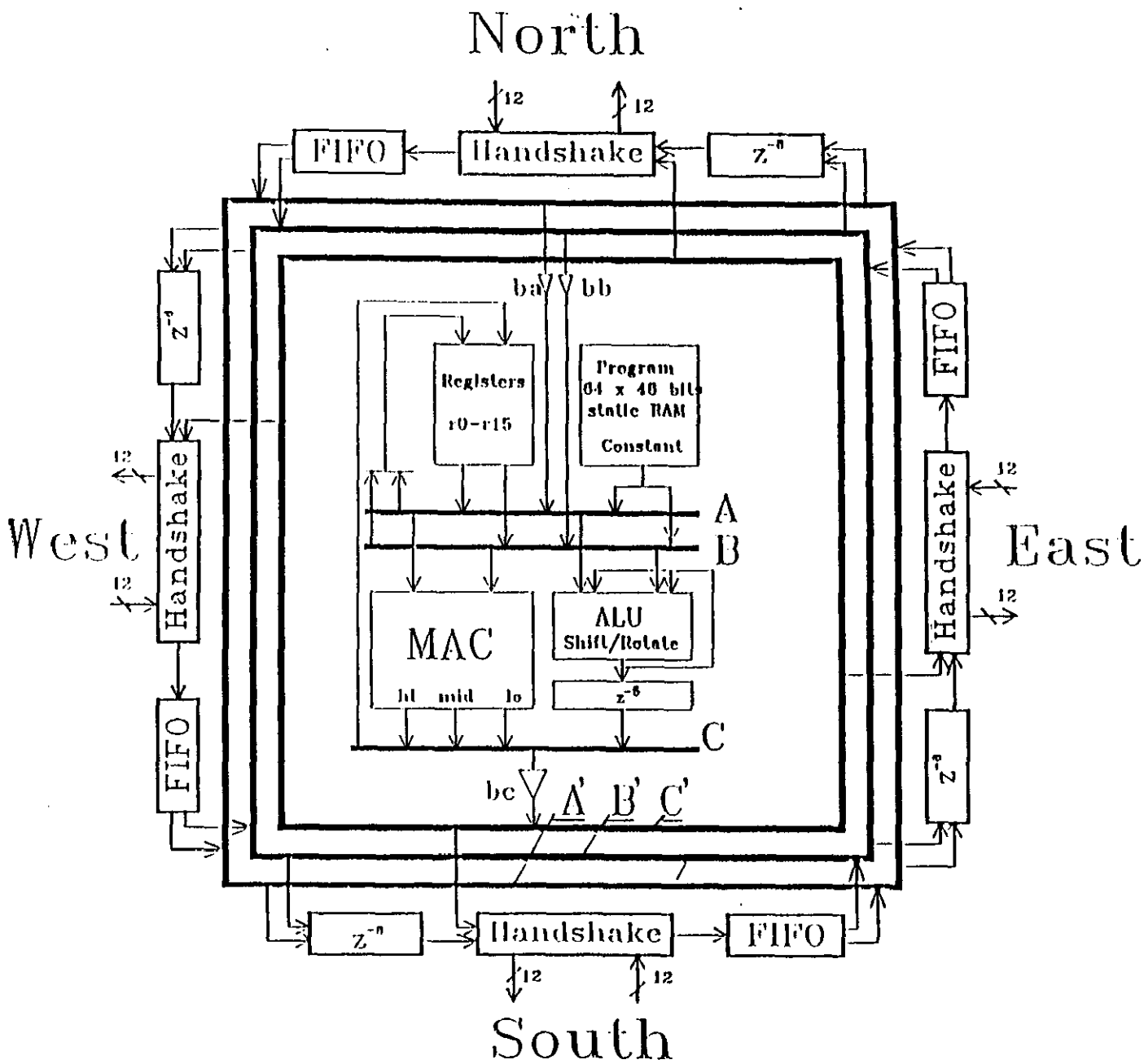
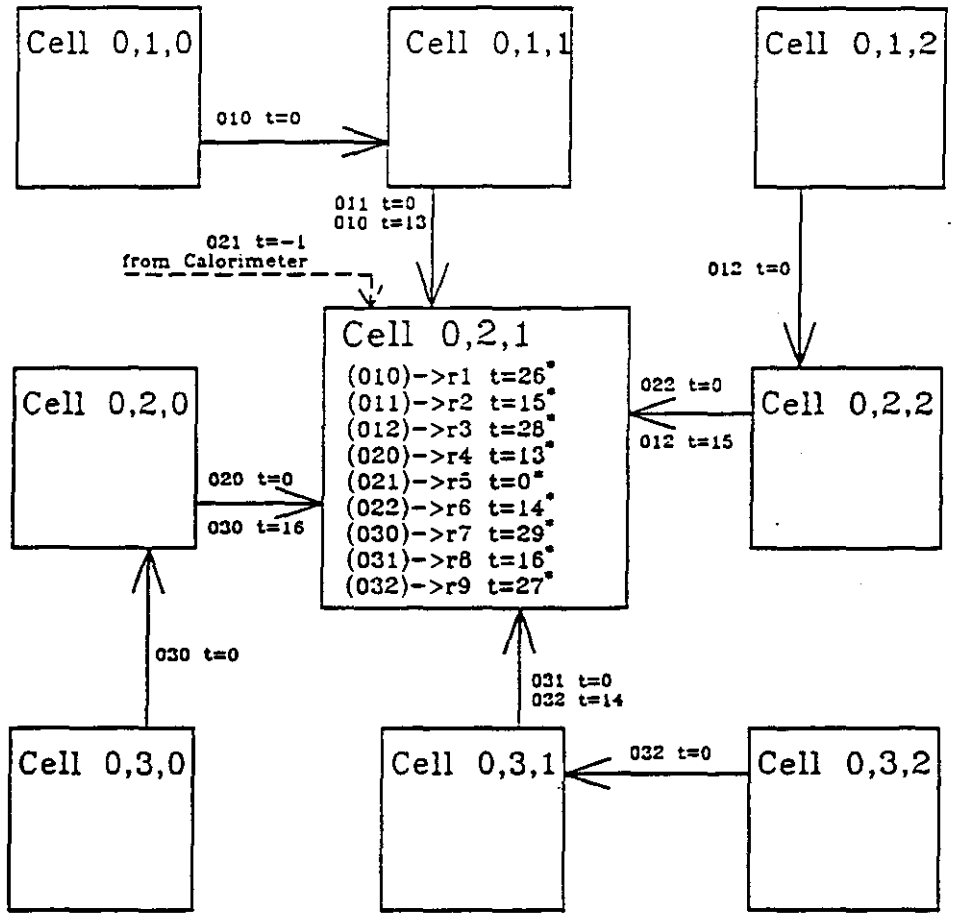

North
West
East
South
Handshake
FIFO
z^{-n}
12
ba
bb
Registers
r0-r15
Program
64 x 48 bits
static RAM
Constant
A
B
C
MAC
hi
mid
lo
ALU
Shift/Rotate
bc
A'
B'
C'

Fig. 7



"*" = fetching time from program in Cell 0,2,1
all other timing is related to time sent

Fig 10

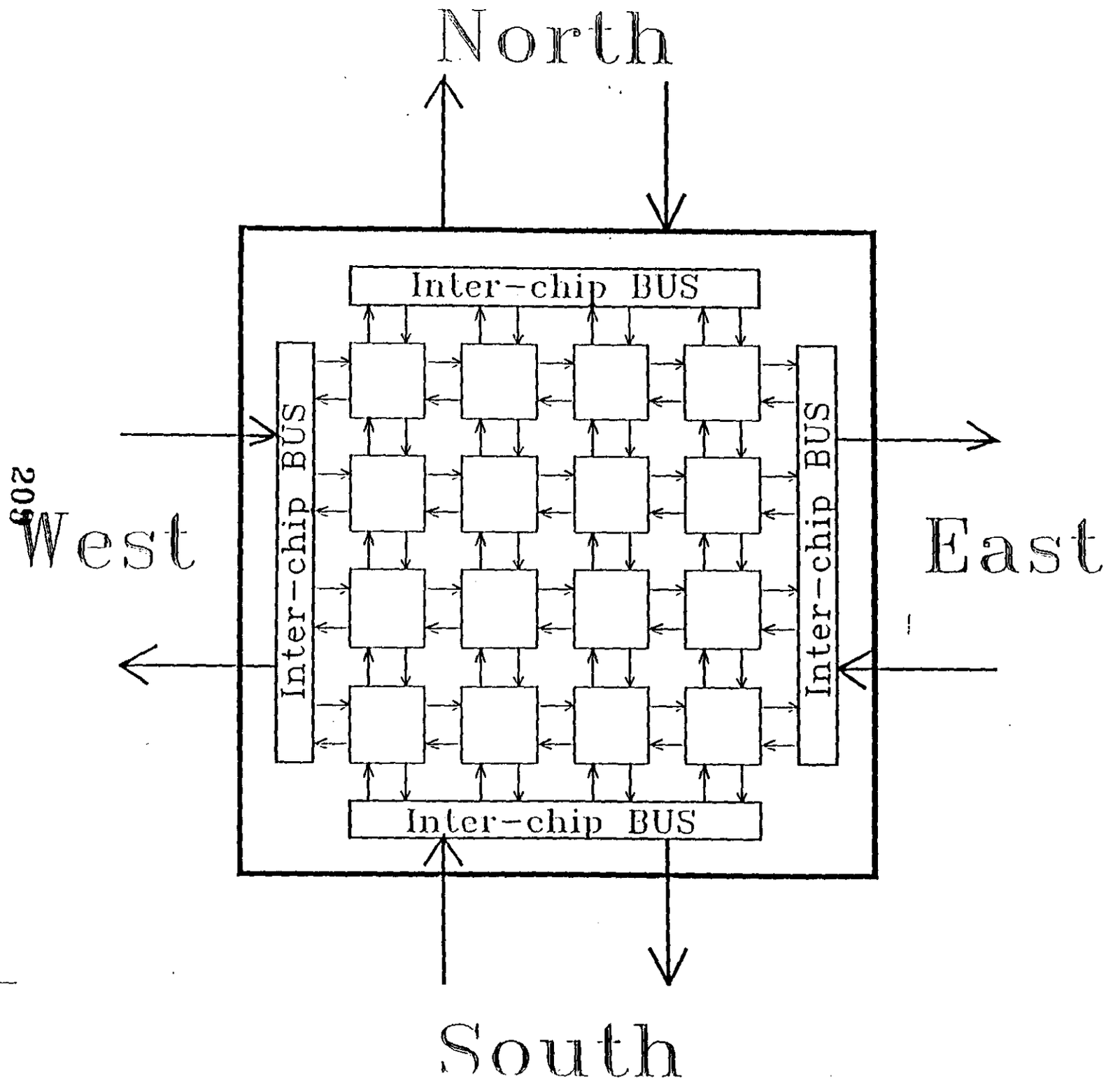

North
Inter-chip BUS
Inter-chip BUS
Inter-chip BUS
Inter-chip BUS
West
East
South

Fig 12

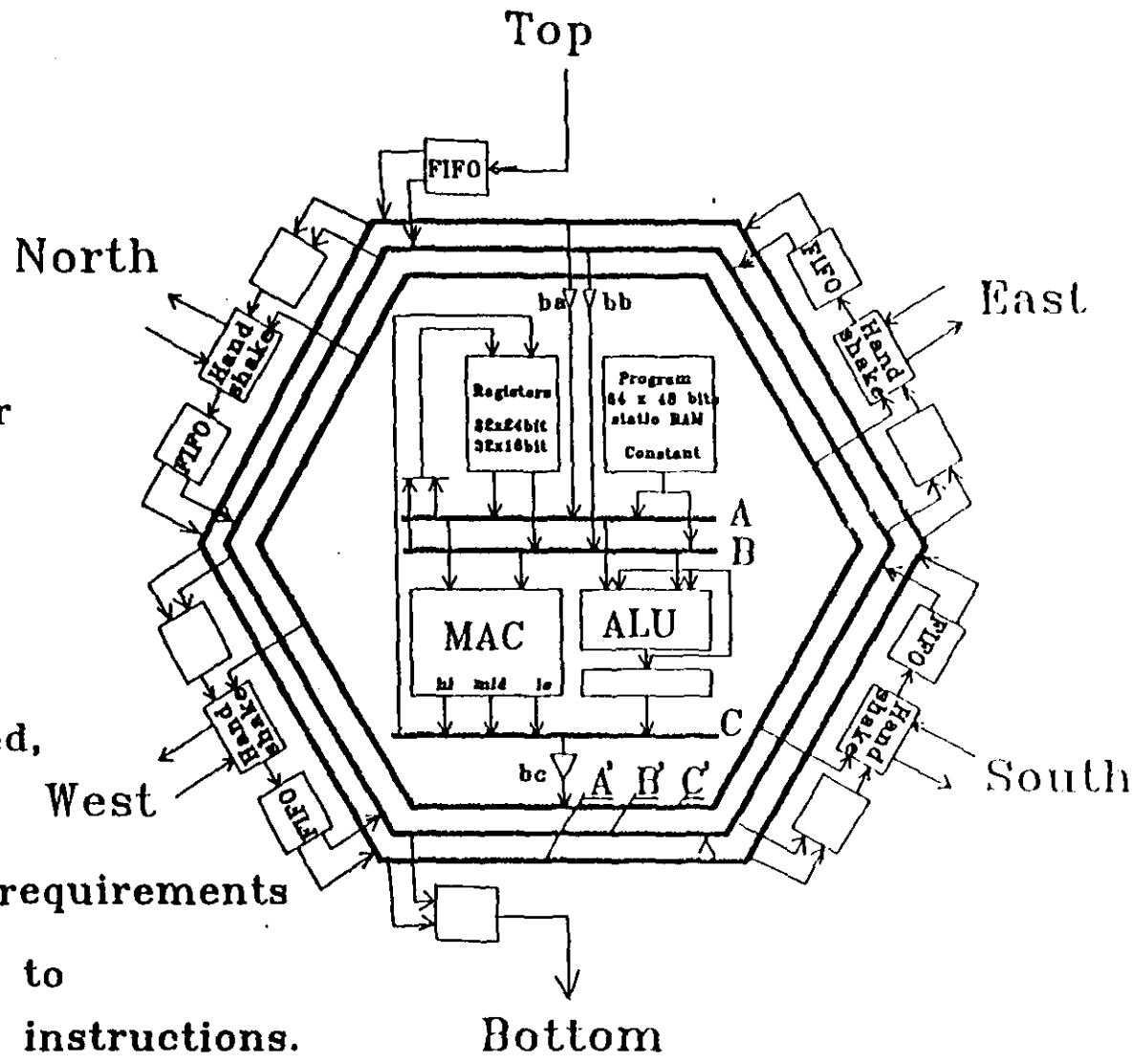
Front-End Processor Cell (FEP)

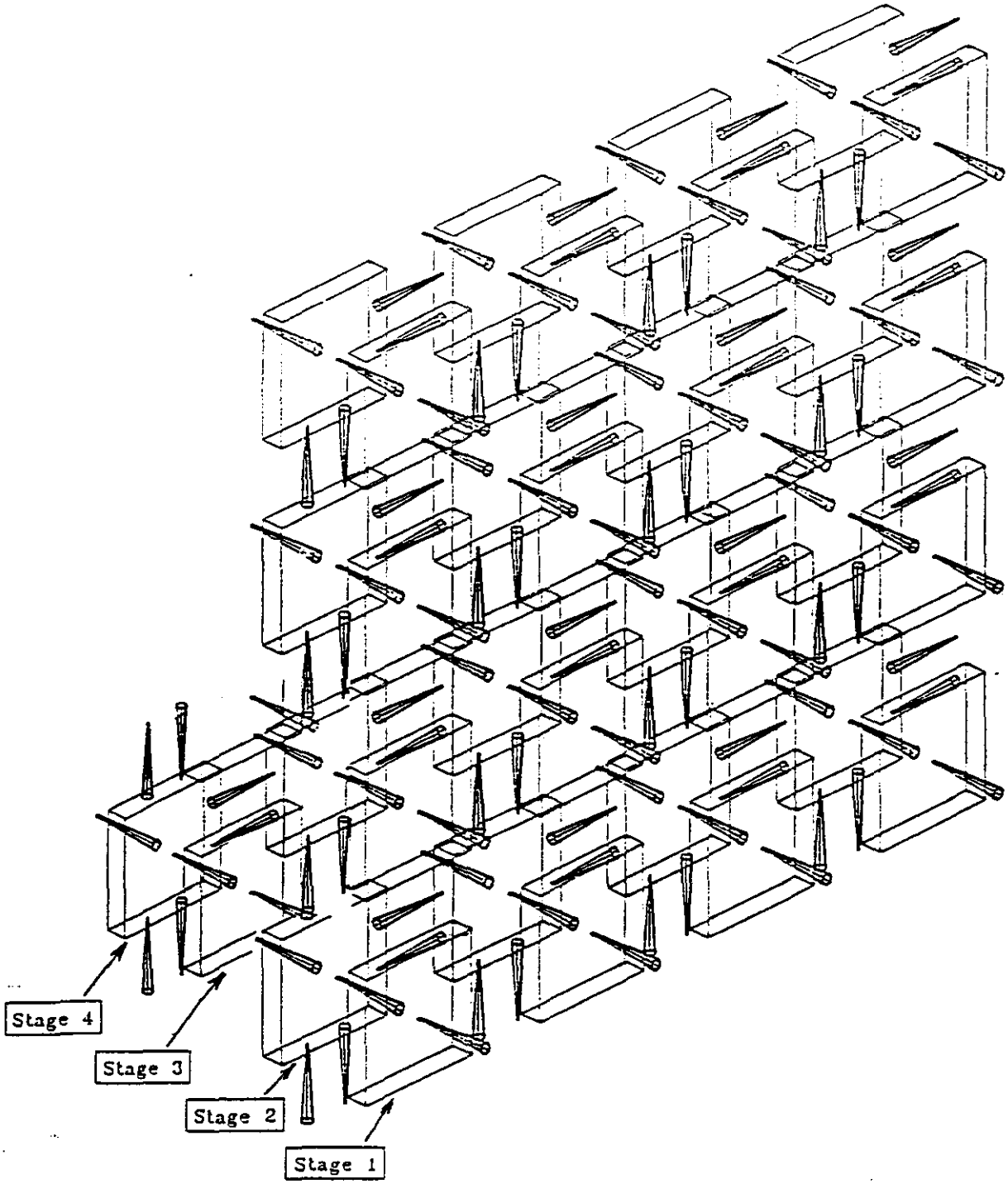
SUGGESTIONS:

either

- to use DAVIS as it is for II level trigger preprocessor if used widely for HDTV at very low cost. OR
- to modify to FEP for I level trigger requirements, and/or more efficient II level trigger preprocessor

- FEP could be simpler, many instructions could be dropped,
- FEP instruction set should meet the trigger algorithm requirements
- Pipeline should be improved to eliminate the need of "nop" instructions.




Stage 4
Stage 3
Stage 2
Stage 1

Comments on GEM CSC Readout

Requirements:

- Low noise ($\sim 2000\ e^-$)
- ~ 10 bits dynamic range
- $< 10\ \mu$s conversion time
- Time resolution $\sim$ BX (for rejection of neutron hits)
- Low cost ($\sim$ \$10. – \$20. per channel)
- Radiation hard? $F_n \simeq 10^{13}\ \mathrm{cm}^{-2}$ ~~s~~ $(10\,\mathrm{yr})^{-1}$

Neutron Rates

- Currently very uncertain
- Product of three factors

$$R = \varepsilon_n F_n A \equiv r_n A$$

where

$$\varepsilon_n = \text{detection efficiency}$$
$$F_n = \text{fluence}$$
$$A = \text{strip area}$$

The efficiency

measured

calculated $\longrightarrow$ $2 \times 10^{-4} < \varepsilon_n < 5 \times 10^{-3}$

the fluence (TN 92-91)

$z = 575$cm

$z = 235$cm $\longrightarrow$ $10^3 < F_n < 10^5 \text{ cm}^{-2}\text{s}^{-1}$

the area

$$A = \ell w \simeq 300 \times 0.5 = 150 \text{ cm}^2$$

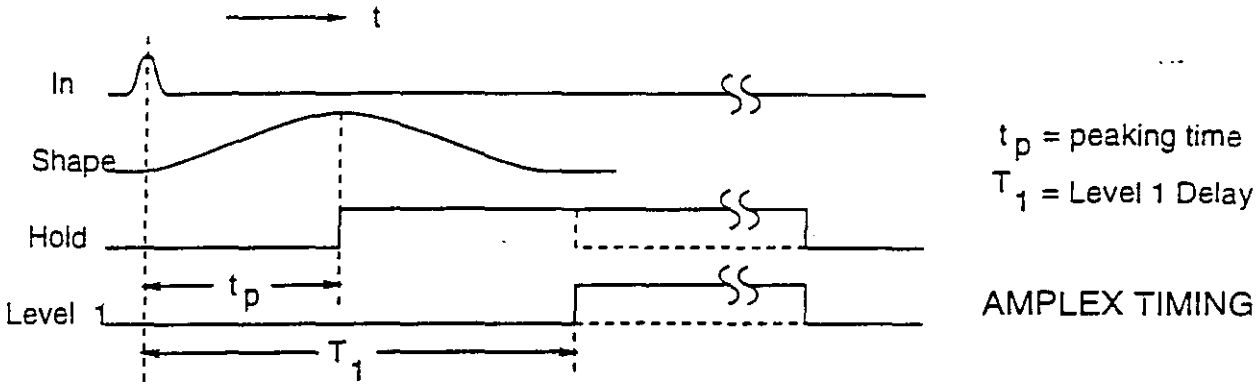
yielding a rate per strip (assuming $\varepsilon_n = 0.5\%$ of

$$0.75 < R < 75 \text{ kHz}$$

note that the corresponding rates per unit area are

$$5 < r_n < 500 \text{ cm}^{-2}\text{s}^{-1}$$

AMPLEX Option



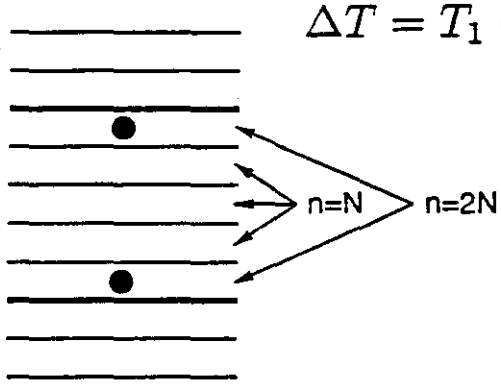
Spoilage Scenarios:

1) Accidental pulse comes early by $\Delta t \leq T_1 - t_p$, causing the hold to be issued too early.

2) Accidental pulse comes late by $\Delta t \leq t_p$, possibly overlapping with the true signal.

Thus the effective total time aperture for spoilage is

$$\Delta T = T_1 - t_p + t_p = T_1 = 2\ \mu\text{s}$$



N = # strips in readout group. (Currently $N = 16$)

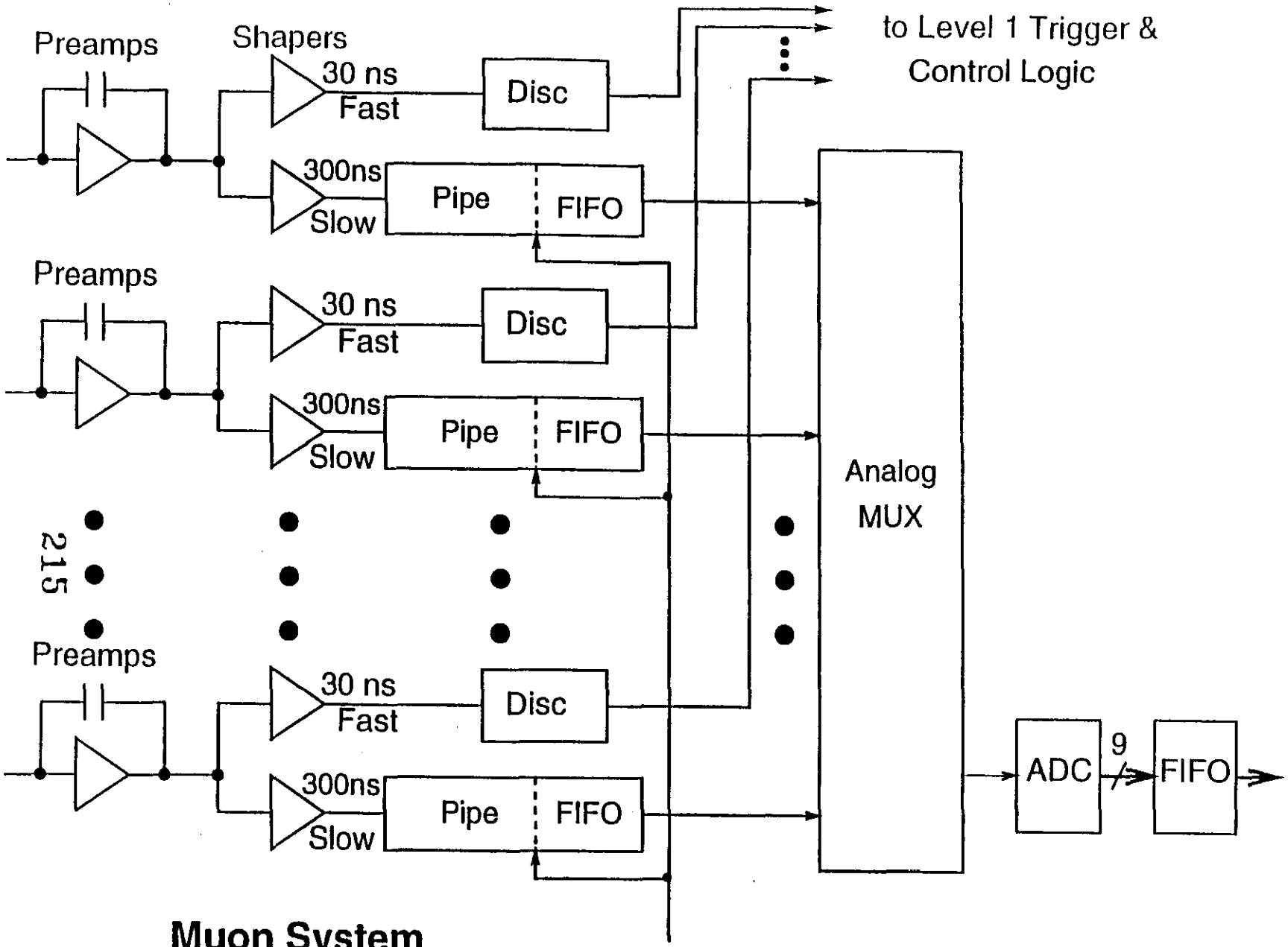
$$N_{\text{eff}} = \frac{(N-2)}{N}N + \frac{2}{N}2N = N+2$$

If we allow

$$p_{\max} = \text{maximum hit spoilage} = 10\%$$

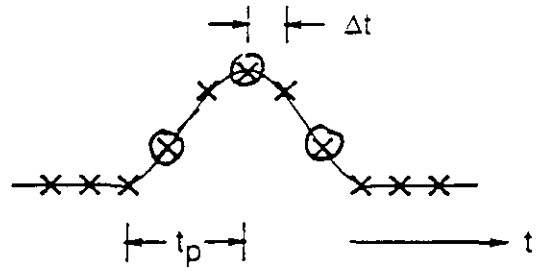
then

$$R_{\max} = \frac{p_{\max}}{N_{\text{eff}}\Delta T} = \begin{cases} 2.8\ \text{kHz}, & N = 16 \\ 5.0\ \text{kHz}, & N = 8 \\ 8.3\ \text{kHz}, & N = 4 \end{cases}$$



Muon System
Cathode Strip Chamber
SCA-Based Readout

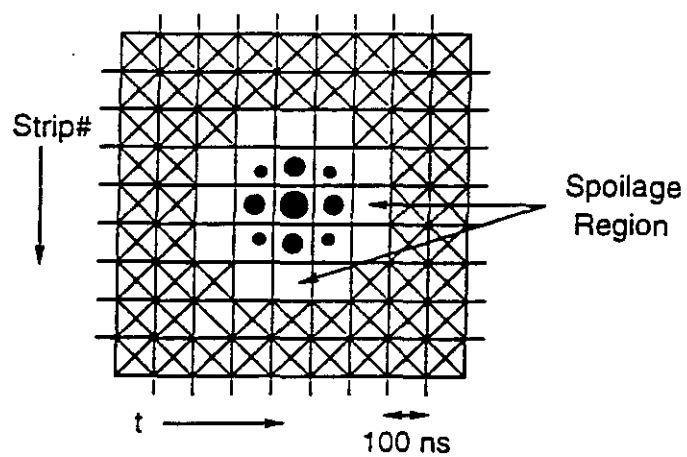
Analog Pipeline (SCA) Option



Assume

$$t_p = \text{pulse peaking time} = 300 \text{ ns}$$

$$\Delta t = \text{sample clock period} = 100 \text{ ns}$$



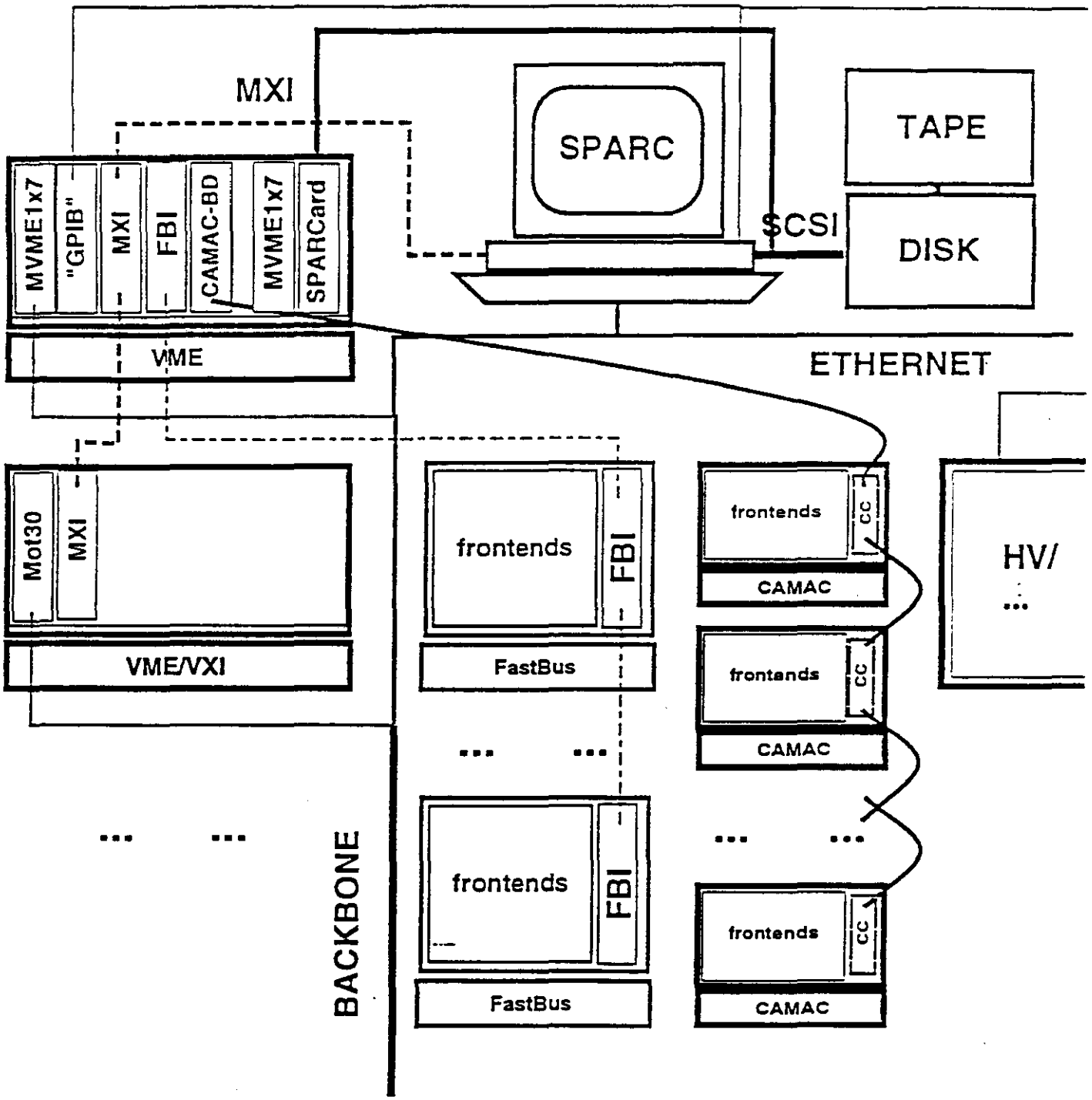
If accidental pulses falling within the indicated region in the space-time grid shown above are considered to spoil the signal pulse, the maximum unspoiled rate is given by

$$R_{\max} = \frac{p_{\max}}{21\Delta t} = \frac{0.1}{21 \times 10^{-7}} = 48 \text{ kHz}$$

(corresponding to $r = 320 \text{ cm}^{-2}\text{s}^{-1}$)

modular [VME]DAQ

Michi Botlo



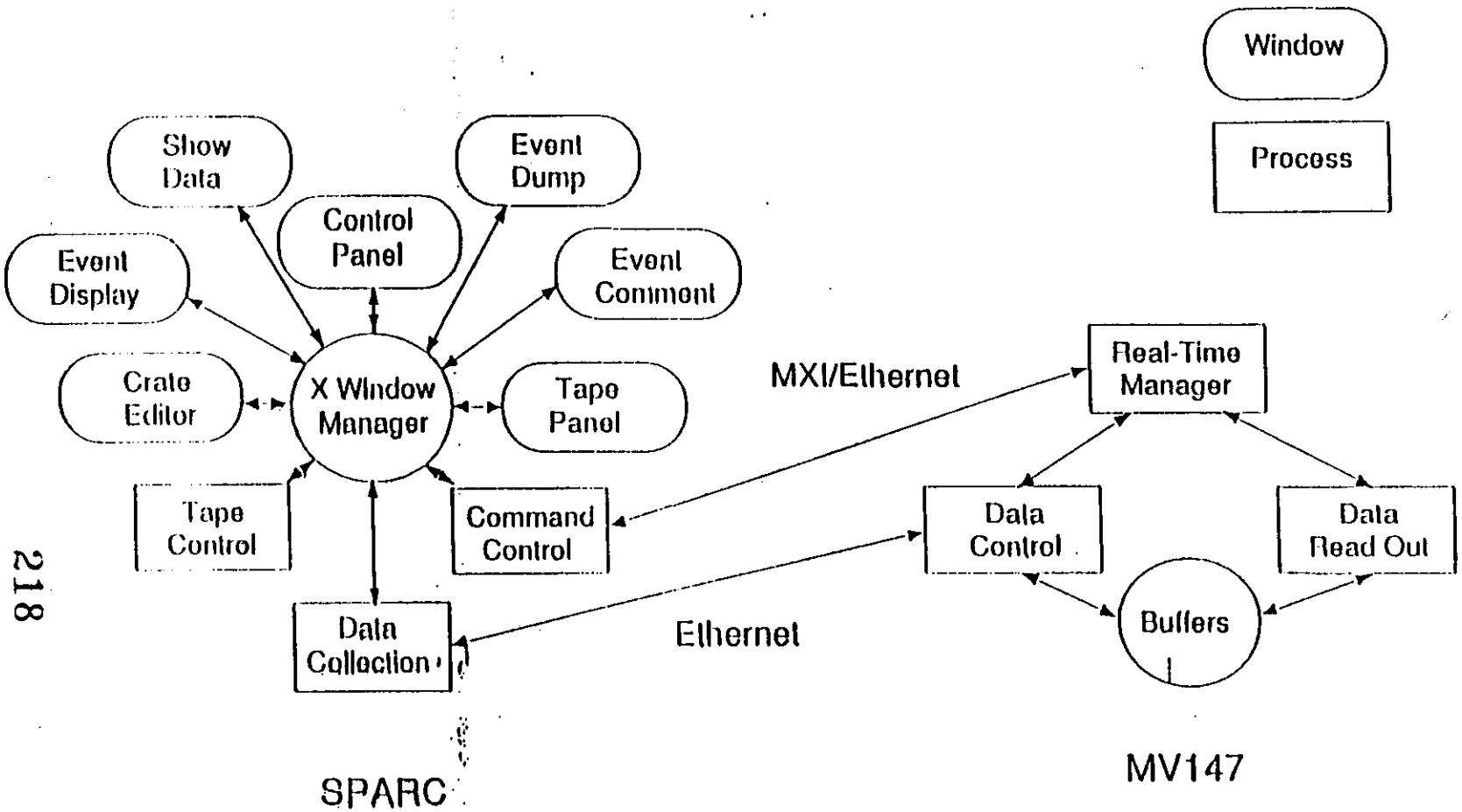


Figure 3.1 TTR Software Configuration
(Ethernet Event Data Link)

gem

γeμ

Presentation by:

J. Musser

Tracker Status

IPC's

- Prototype tests
- Front End Design status

J. Musser
SSCL
Aug 92

GEM

Si Tracker Progress

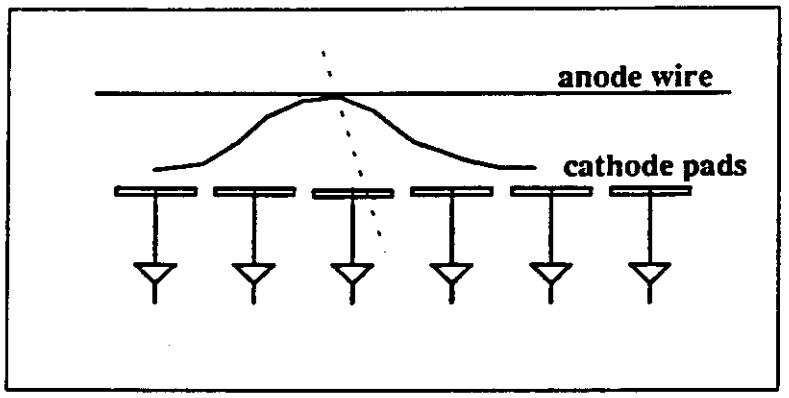
- Simulation: Full GEANT tracker simulation to work on H-$\gamma\gamma$ (γ id)

- Mechanical: Evaluate strip vendors
  Outer enclosure design
  Cooling ring / ladder assembly
  Thermal modeling
  Space frame design studies.

- Electronics: Bid out for Bipolar ASIC amp - AT&T.
  Developing CMOS layout tools
  Simulations on UTMC on pipeline IC.
  Investigating GE/TI HDI for MCM's.

IPC - Principle of Operation

Wire chambers with readout of sgemented cathode plane.

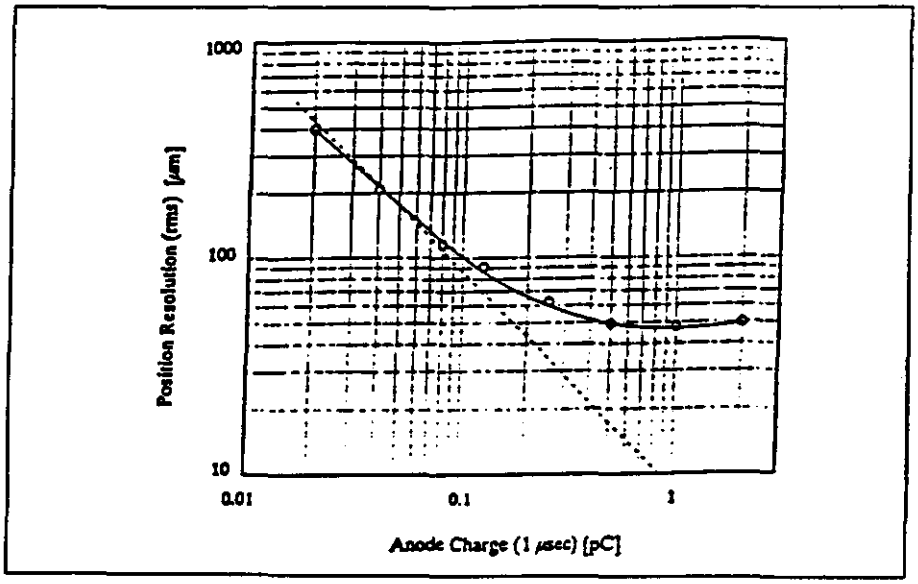


Position obtained by calculating weighted average of signals seen on cathode pads.

Design Goal : 50 micron resolution
Pads arranged in stereo layers with
60 mr stereo angle to obtain 700 micron/layer
z resolution.

Outer Tracker Resolution

For low gas gain, position resolution dominated by electronics S/N



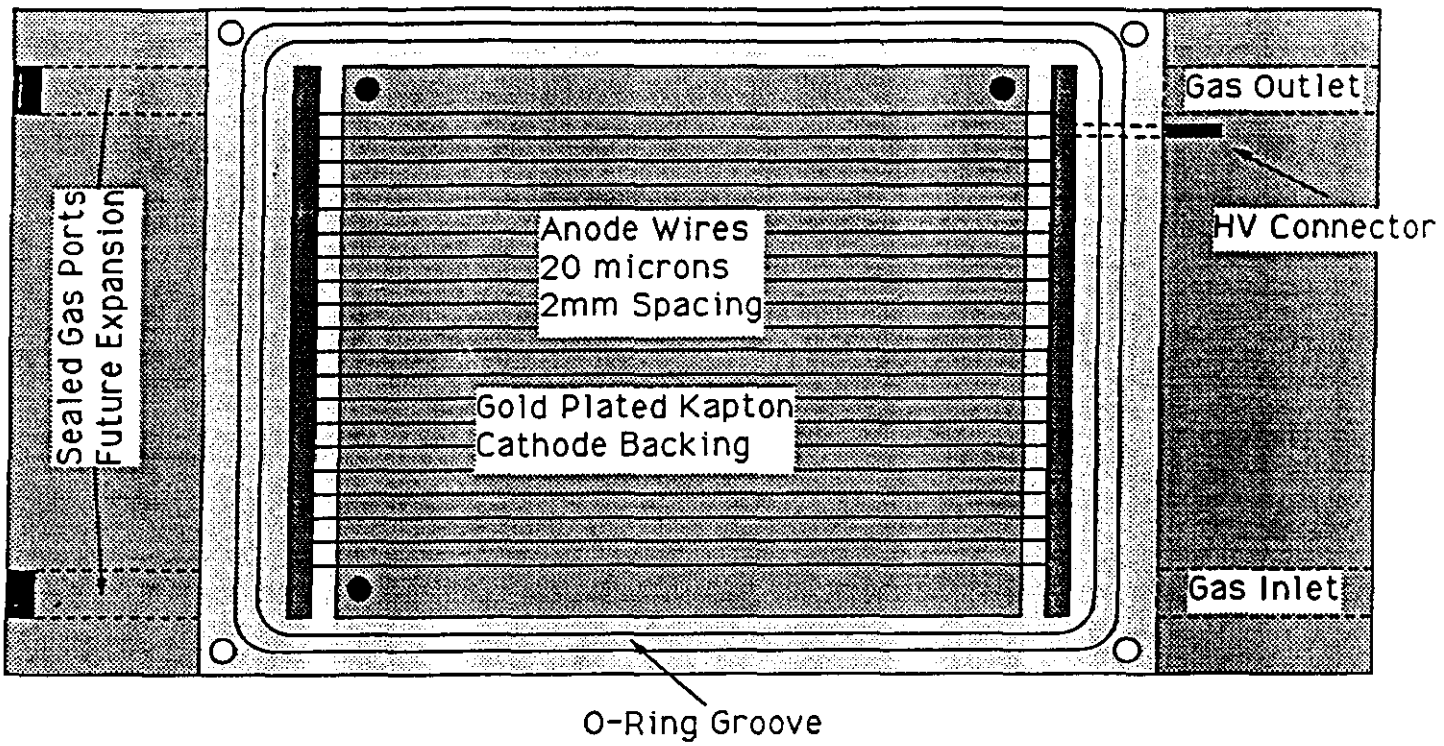
- $S_{tot}/N > 200$

  Set by 50 micron Position Resolution Req.

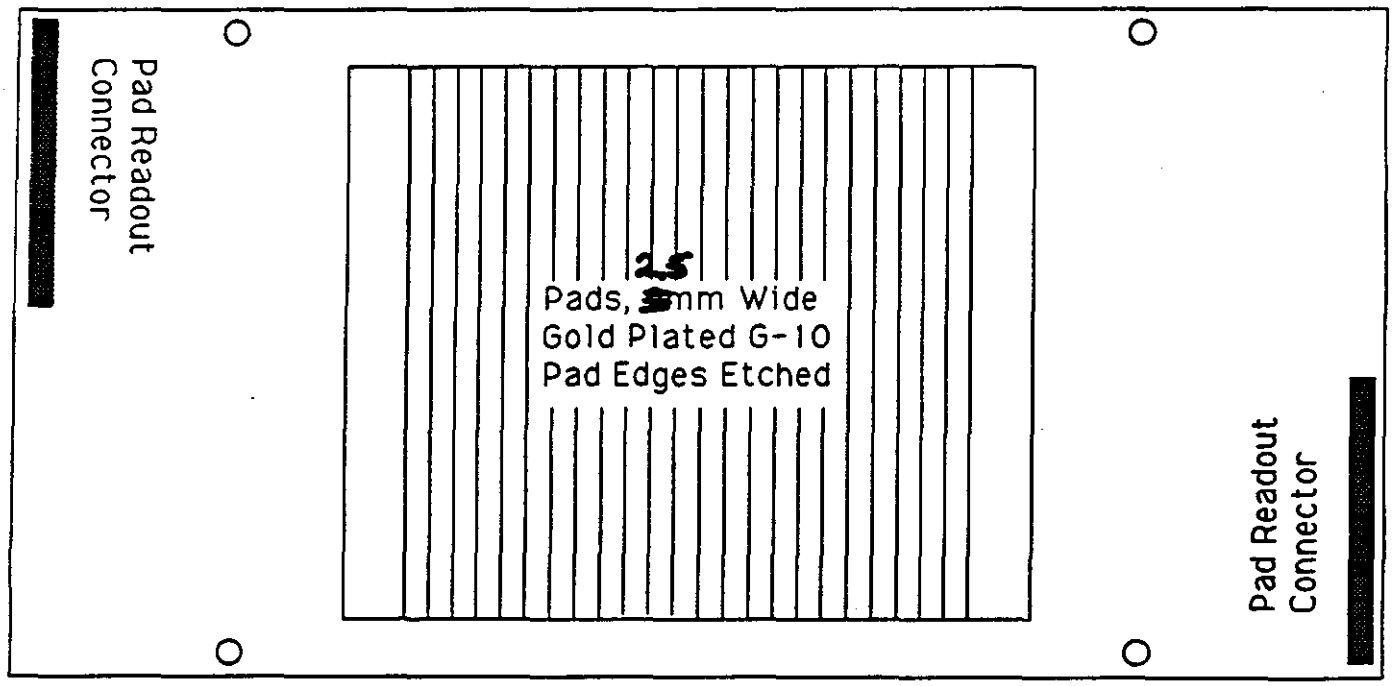
Pad Width = 2.5 mm

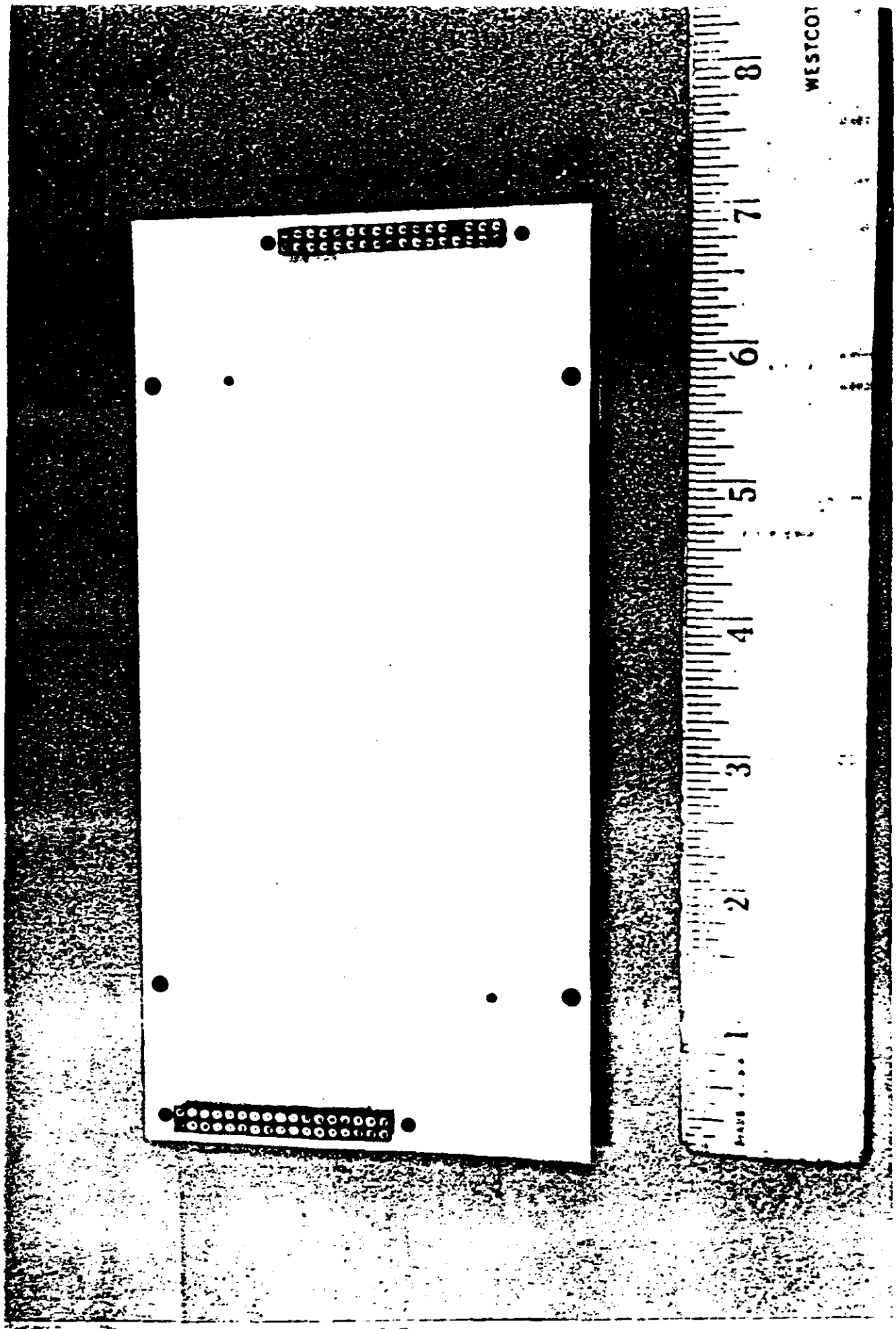
$$\frac{\sigma_x}{2.5mm} \cong \sqrt{3}\,(s_{tot}/n)^{-1}$$

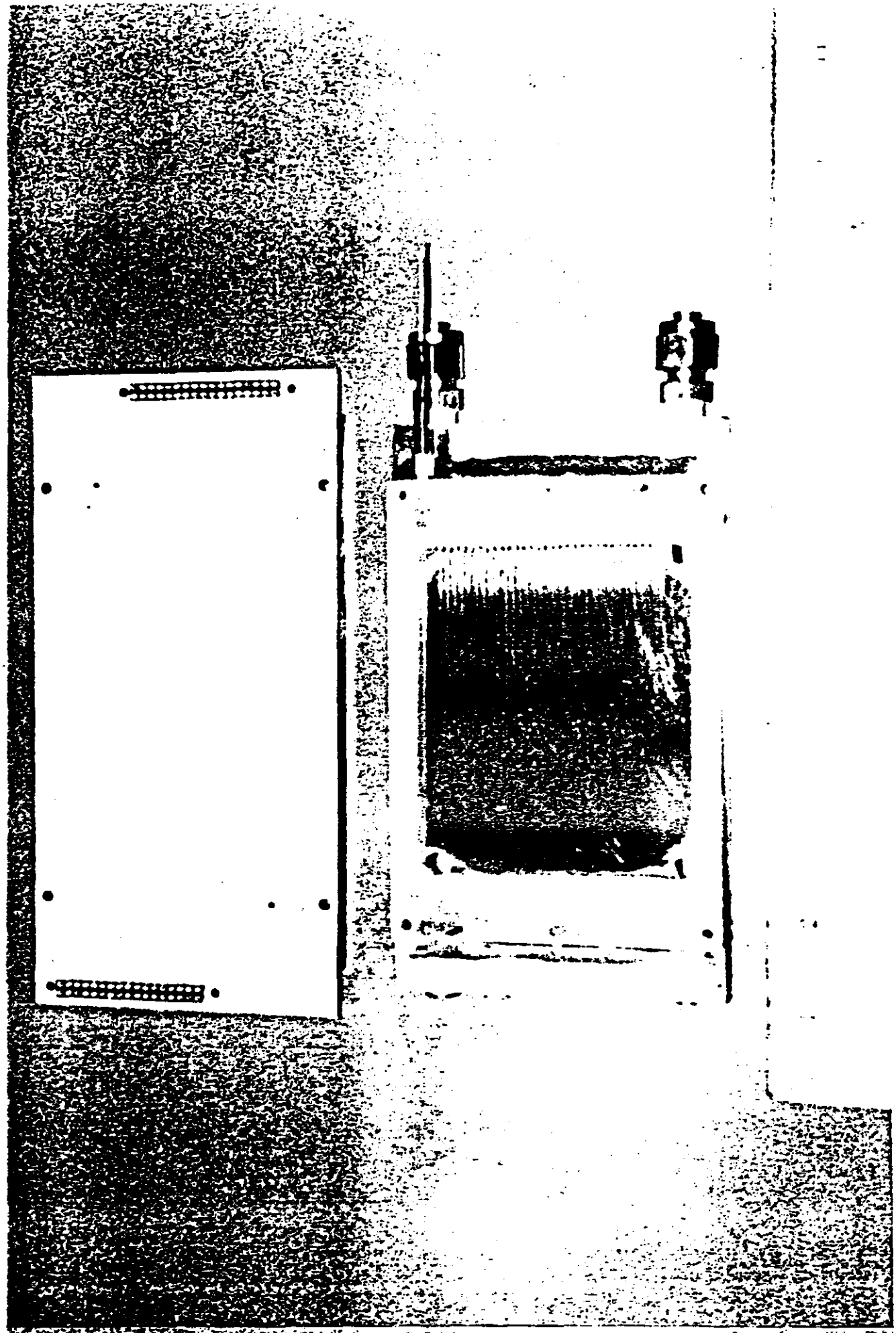
Anode Board



Pad Board



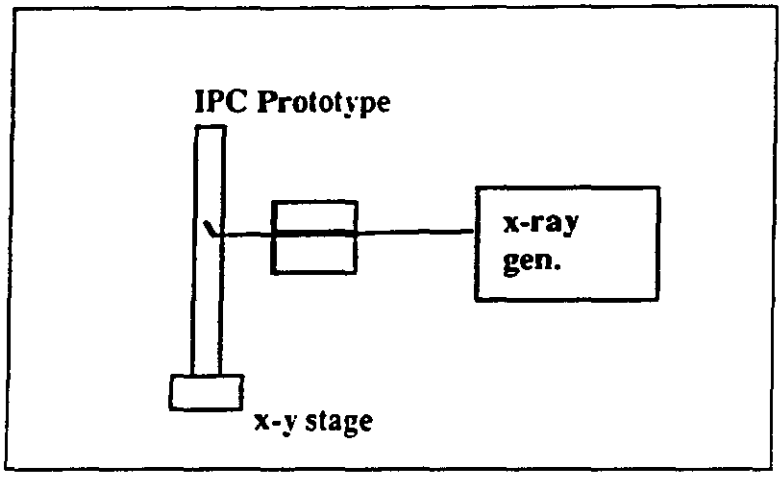

WESTCOT
8
7
6
5
4
3
2
1



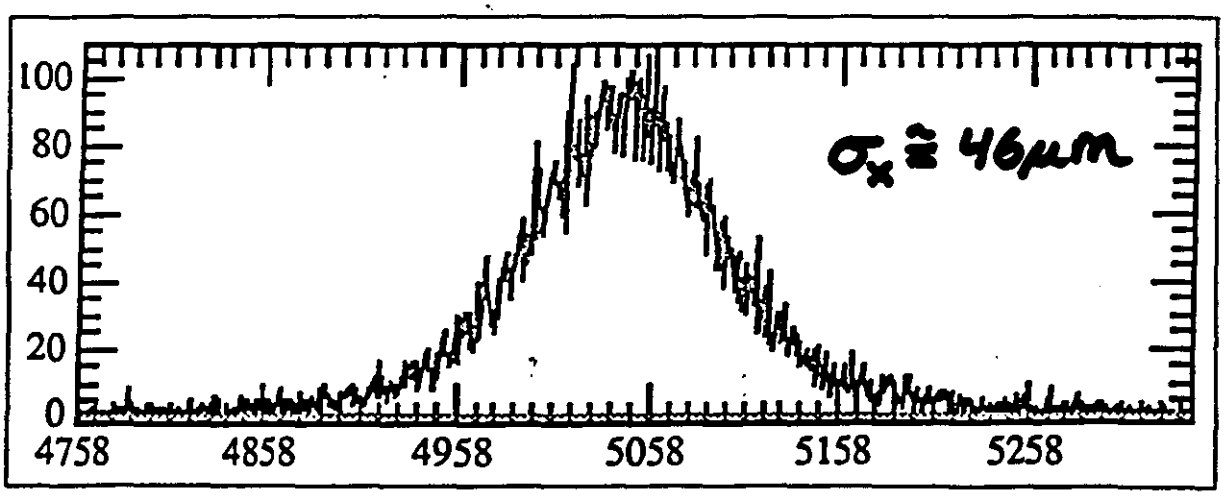
Central Track Status

IPC Prototype Tests

<50 micron position resolution achieved in x-ray studies



100 ns peaking time
~ 20 micron resolution
from electronics noise

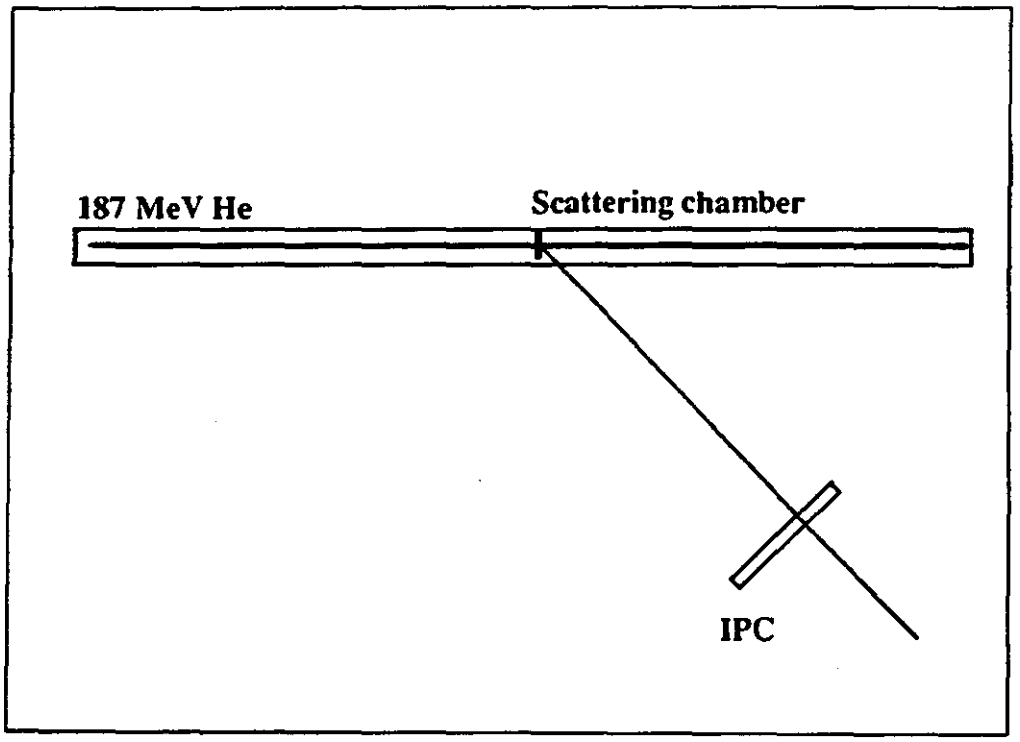


Central Tracker Status

IU Cyclotron Tests

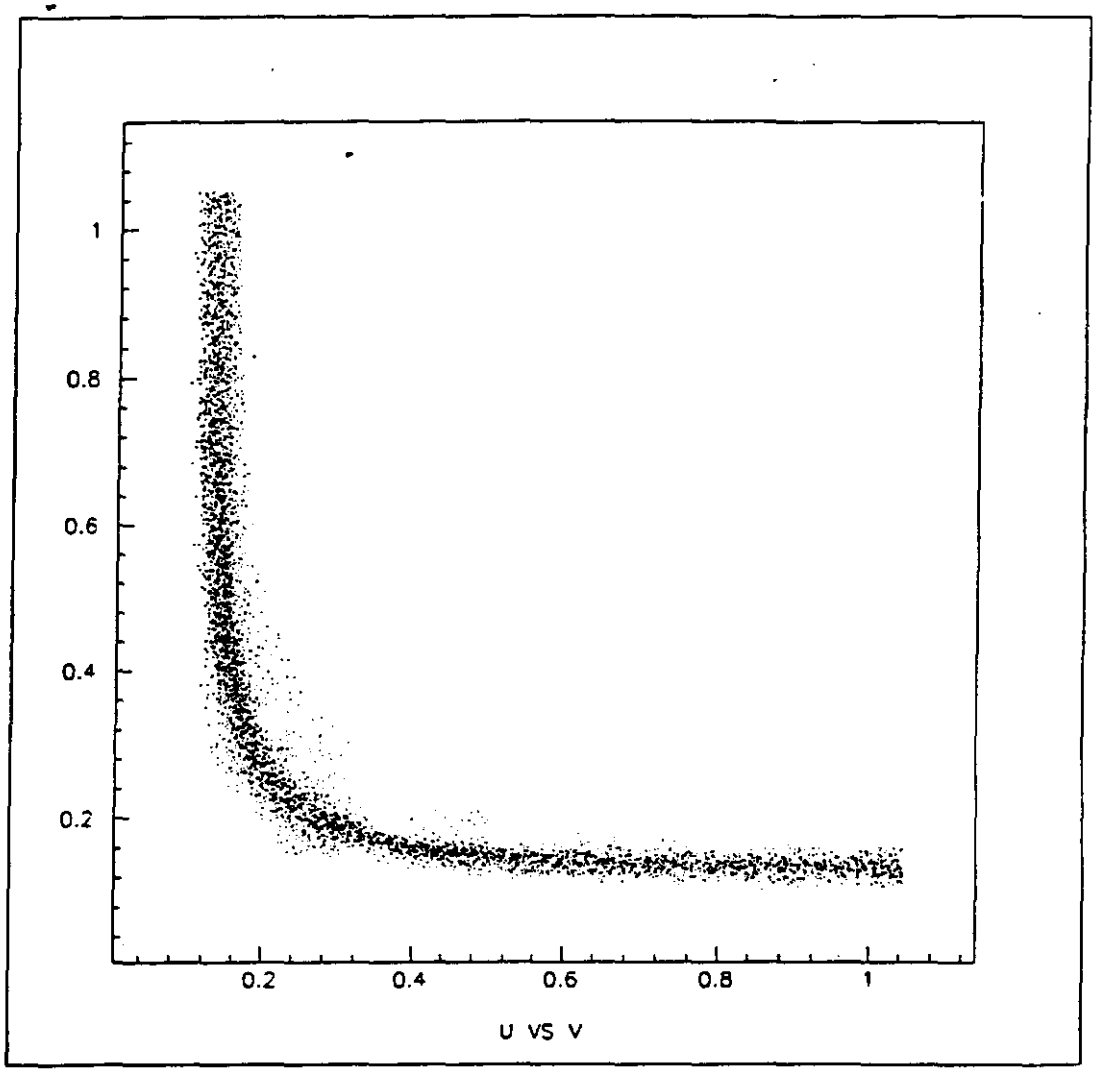
180 MeV He Beam - scattered off Carbon target.

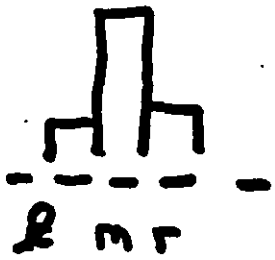
chamber gain lowered to compensate for higher primary ionization



Multiple coulomb scattering doesn't allow standard resolution measurement using telescope.

IPC Response





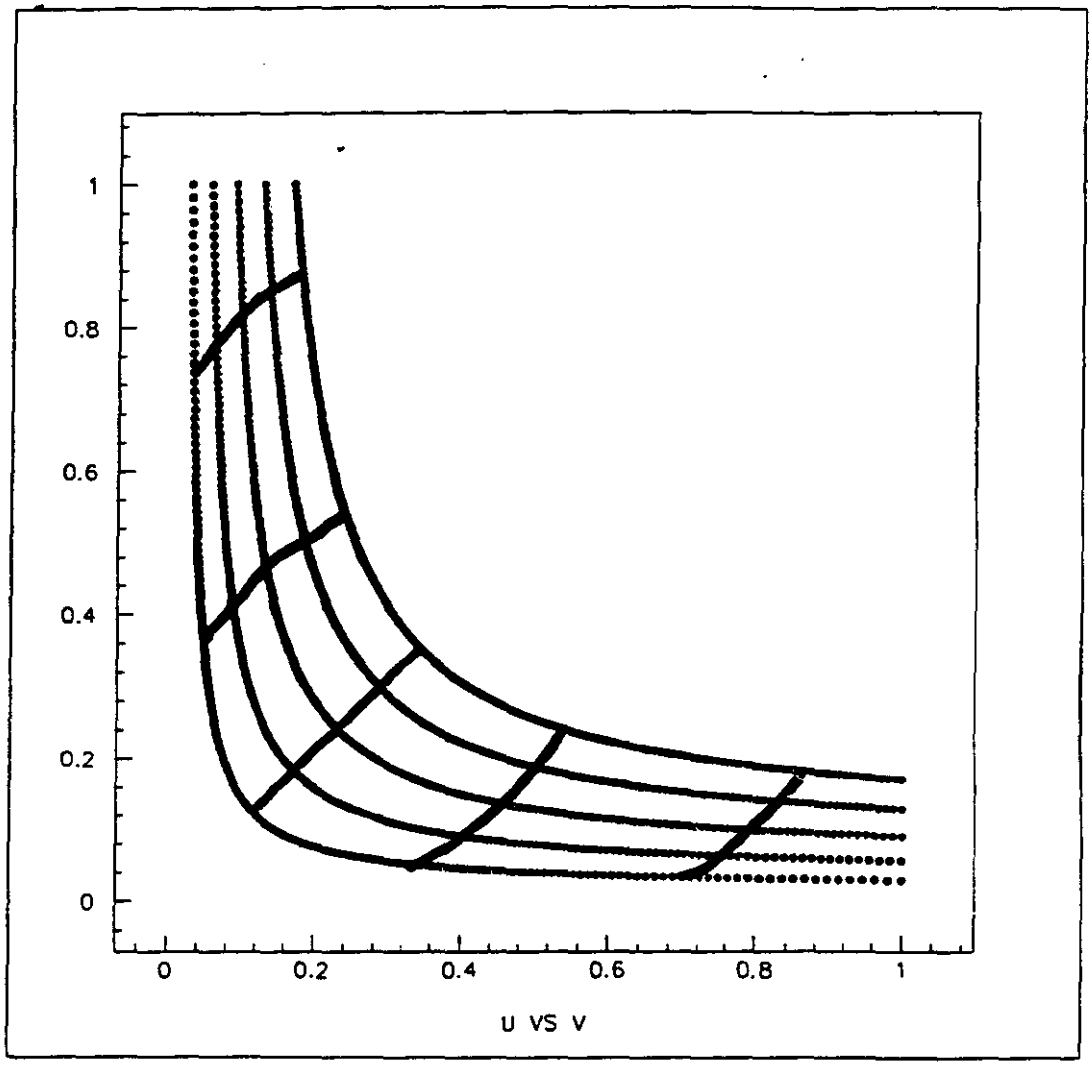
$u = \ell/m$

$v = r/m$

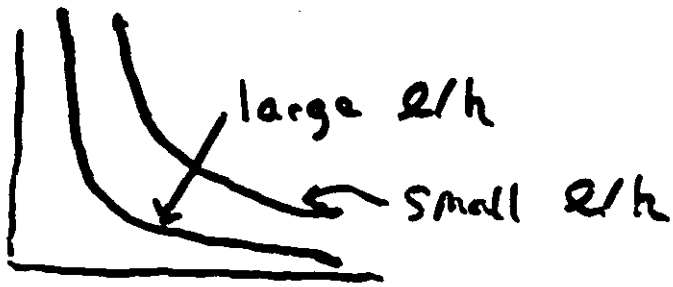
u,v - two measurements of position

⇒ allows position resolution determined from one chamber

IPC response



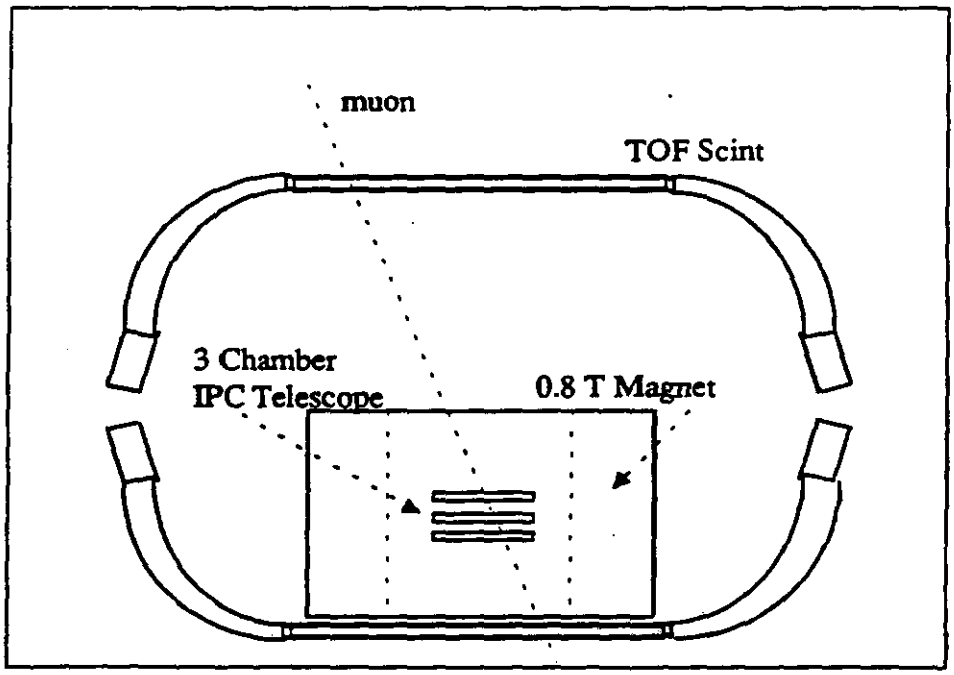
u-v curves - family depending on chamber geometry.



Central Tracker Status

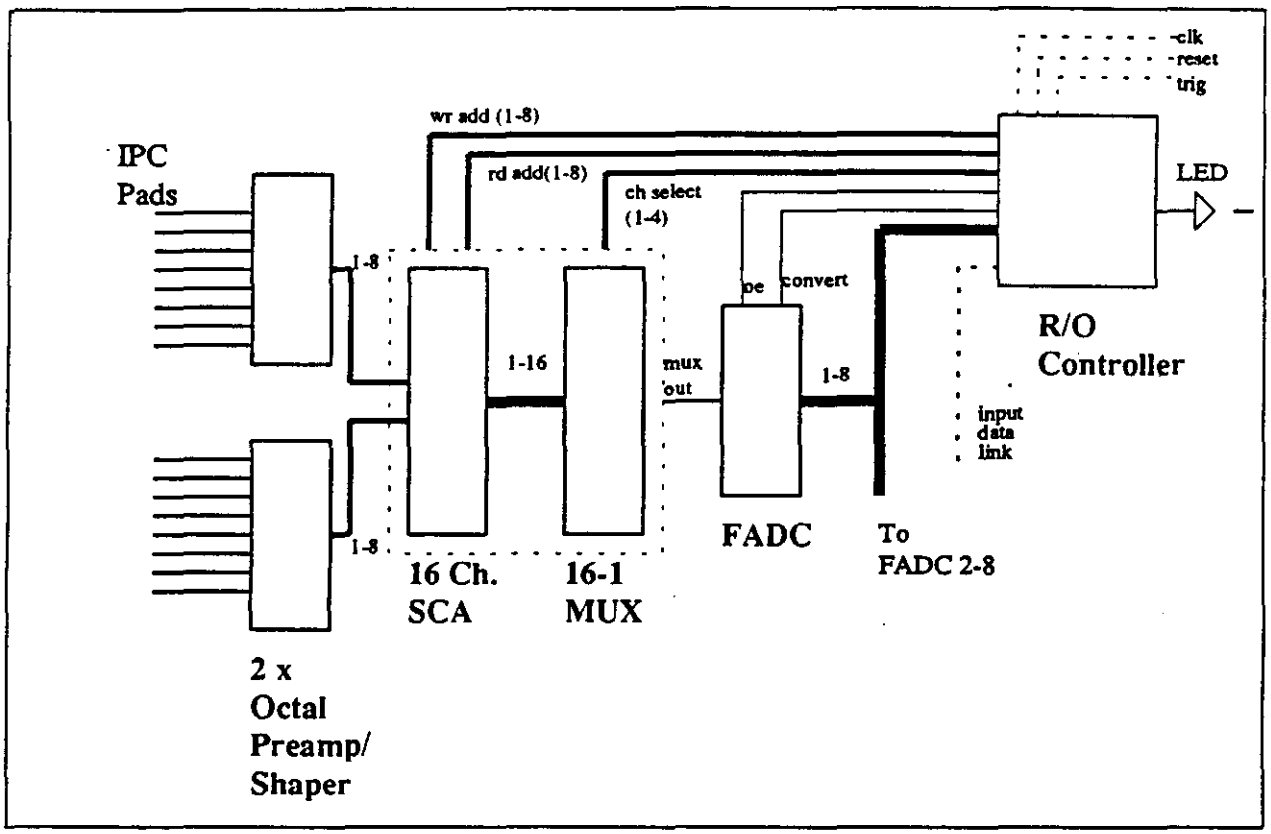
Upcoming Studies

- x-ray resolution study using 25ns peaking time shaper
- position resolution - fast electronics - no B field, with muon telescope
- position resolution - fast electronics - B field, with muon telescope



position in TOFs determined to ~2 cm ~~from timing~~ L/R timing

Outer Tracker Readout



Components:

Octal Preamp/shaper	1 per 8 ch.s
16 Channel SCA/MUX	1 per 16 ch.s
8 bit FADC	1 per 16 ch.s
R/O Controller	1 per 128 ch.s
Output Data Link	

Central Tracker Status

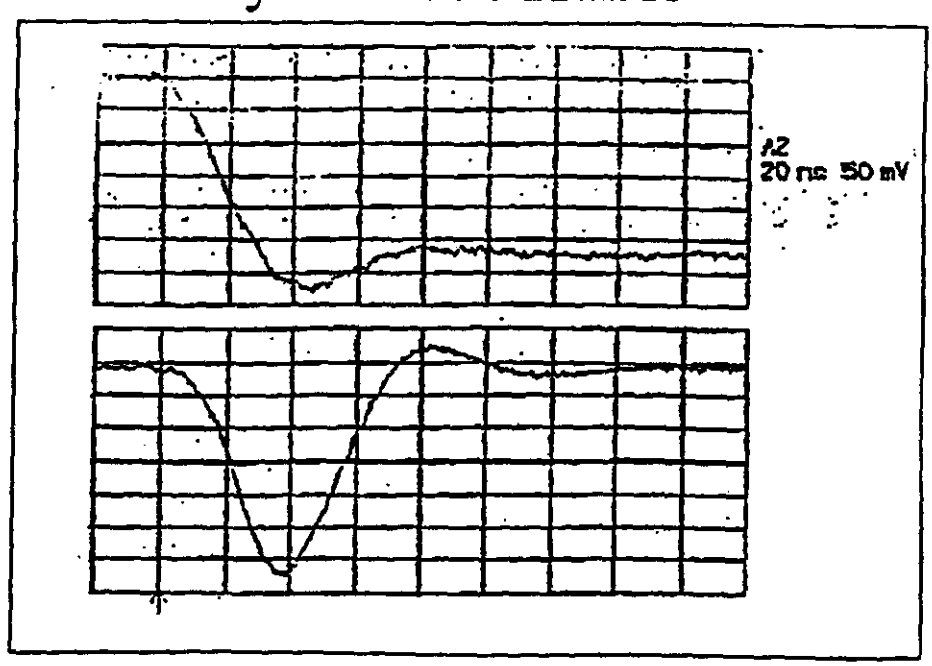
Tront End Electronics

8 channel preamp/shaper prototype has been fabricated in 2 micron ORBIT process.

Device now under test at BNL

Peaking Time: ~25 ns
Gain: 3.5 V/pC
Noise: Needs optimization - shaperr contribution too large

Modified design will be layed out in Harris rad-hard process for Oct fab run



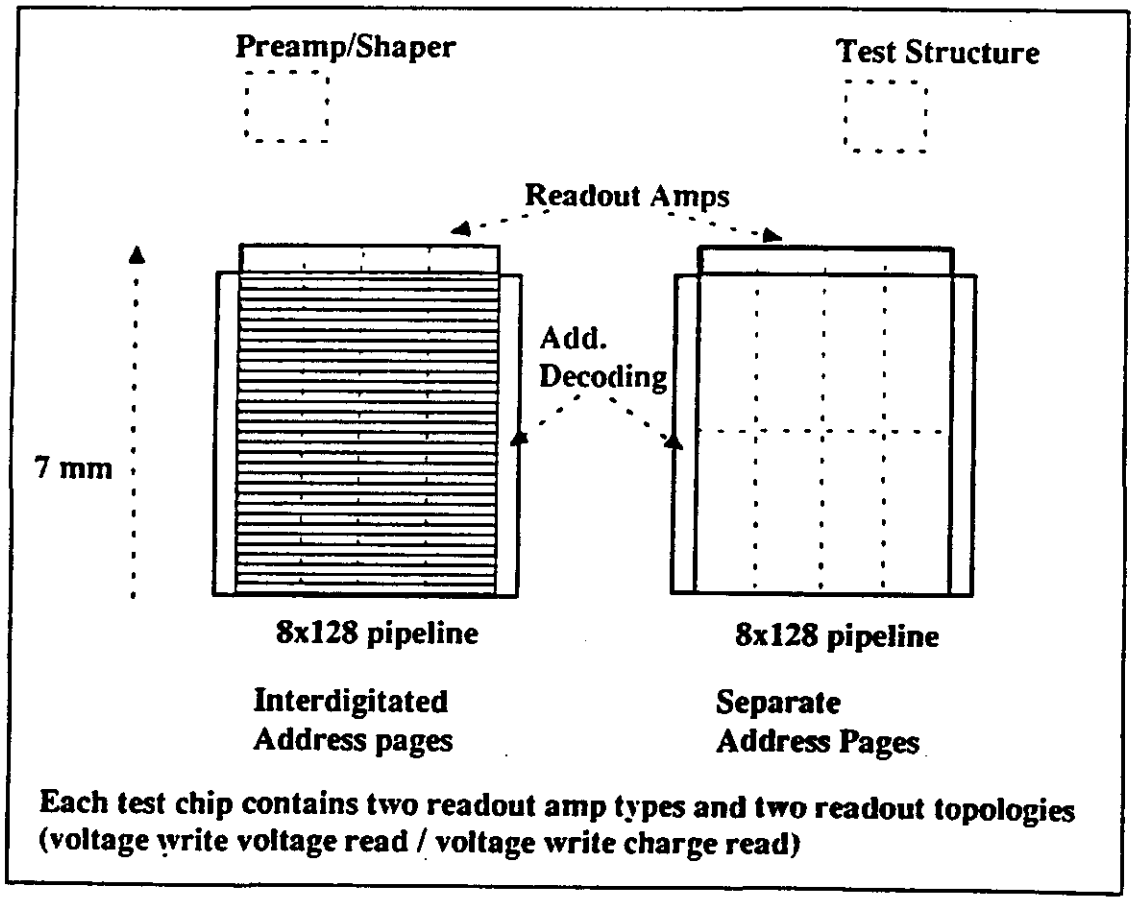
Central Tracker Status

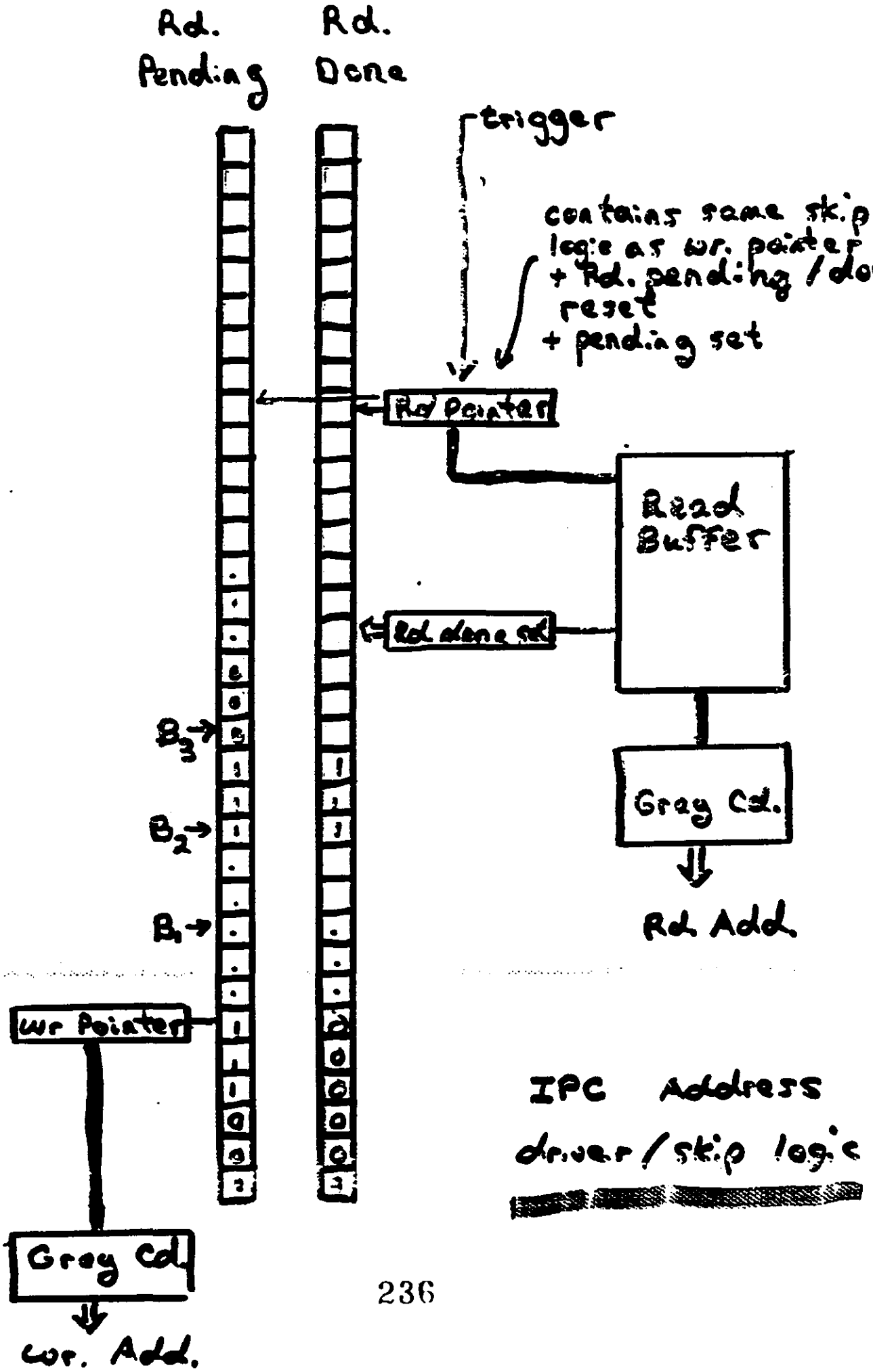
Analog Pipeline Prototype

8 channel, 128 deep rad-hard SCA now in final stages of layout by ORNL in Harris AVLSI-RA process.

Design review at Harris in mid-September.

Fab run start - mid October





IPC Address driver / skip logic

Rdout Controller

- E.E. now working @ I.U. on detailed design
- Prototype implimentation will be on FPGA - to be completed in mid 93'

will combine with prototype amp/SCA + commercial FADC and instrument full scale chamber prototype fabed @ Yale in mid 93.

gem

γeμ

Presentation by:

J. Proudfoot

J. Proudfoot
4/8/92

Calorimeter Subsystem

Status.

Design ≡ TDR + "Minor" Change

Barrel EM :- Design review at this meeting

Barrel HAD :- "Dogleg" revisited at this meeting

Endcap :- Decision schedule established.

Barrel Pre-Production Prototype. :- Much work in progress.

SPECIAL BARREL EM DESIGN REVIEW

MONDAY AUGUST 3

REVIEW COMMITTEE:

M.Banas,A.Bodek,G.Foster,W.Frisken,R.Hubbard,J.Krebs, J.Siegrist,K.Takikawa,W.Thur

CHARGE:

Determine if the cast lead EM design team has satisfactorily solved the structural problems and addressed other concerns raised in the June 22-23 Cast/Stacked EM review. Make recommendations as necessary.

AGENDA:

1:30 Introduction - P. Mantsch

Review of the mechanical design

EM design including the EM/HAD connection - N. Hill

Assembly Scenarios - N. Hill

Source tube location and calibration precision issues - R.G. Wagner

3:00 Break

3:15 Review of the optical system

Test Module data analysis - R.G. Wagner

Scans of beveled tiles - J. Proudfoot

4:30 Other EM issues (not part of the review)

Report on the stacked lead model tests - M. Banas

Discussion of photo-electron yield - J. Proudfoot

5:00 Discussion

5:30 Closed session of the review committee.

Barrel EM Design Modifications

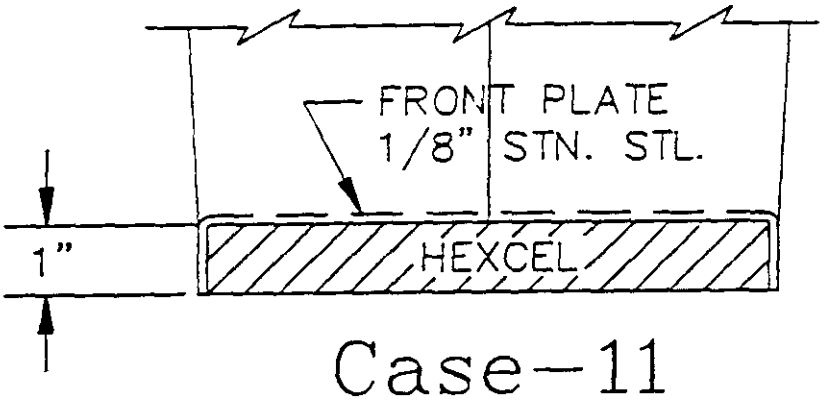
1) Plate attachment at 90° end

2) Ca/Sn Lead alloy

3) Hexcell stiffening plate attached to EM Front Plate

4) Reinforcement tubes within the Lead plates at high η.

All changes associated with increased deflections resulting from accomodating 0.2 $\Delta\eta$ space for SMD.



Case–11

LEAD ALLOY MODULUS: 3,000,000 PSI
EVERY OTHER BULKHEAD PENETRATING SHOWER MAX. AT eta = .2
END PLATE FIXED AT Z=0
32 MODULES/BARREL

Location		Bulkhead Displ.		Max. Lead Displ.		Cell Displ.		Case 11
ETA	Cell	ΔZ (mm)	Δr (mm)	ΔZ (mm)	Δr (mm)	ΔZ (mm)	Δr (mm)	
0-.2	1	0	0	.006	- .022	.006	- .022	Max. frame stress = 2,200 psi
0-.2	7	0	0	.016	- .022	.016	- .022	Max. bulkhead stress = 2,200 psi
.6-.8	1	.016	-.020	.027	- .071	.011	- .051	Max. lead stress = 246 psi
.6-.8	7	.011	-.015	.101	- .140	.090	- .125	in 3rd lead plate at eta = 1.4
1.2-1.4	1	.024	-.051	.040	-.334	.016	-.283	
1.2-1.4	3	.049	-.097	.119	-.705	.070	-.608	
1.2-1.4	8	.115	-.190	.127	-.672	.012	-.482	
1.2-1.4	18	.013	-.016	.019	-.284	.006	-.268	

Figure 9

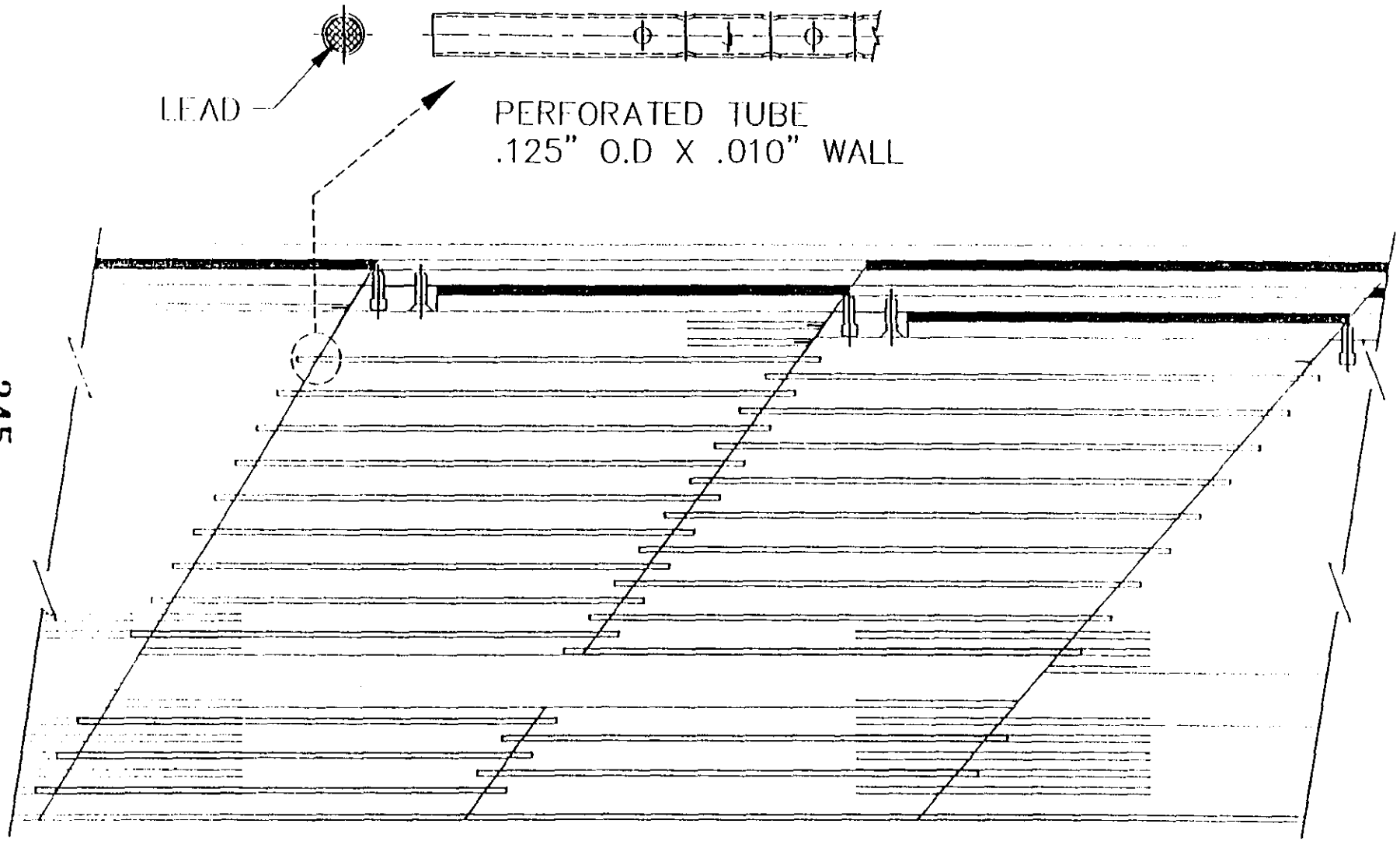


Figure 18

Figure 17

Special Barrel EM Design Review

Conclusions and Recommendations

1) The Deflections in the cast lead structure seem to be controllable. Two concerns remain, however.

Details of the 90 degree attachment point

Creep in the lead

2) The method for tile/fiber assembly installation into the gap needs to be developed. Will the tile/fiber system be load bearing? What are the mechanics and economics?

3) Cost increments must be developed for design changes:

Hexcell support and corresponding colorimeter size growth

Reinforcement tubes

Tile mechanics

Source tubes including those that access the shower max detector which must exit at 90 degrees

Fixturing for supporting modules during assembly and installation

Extra QA costs for alloy monitoring

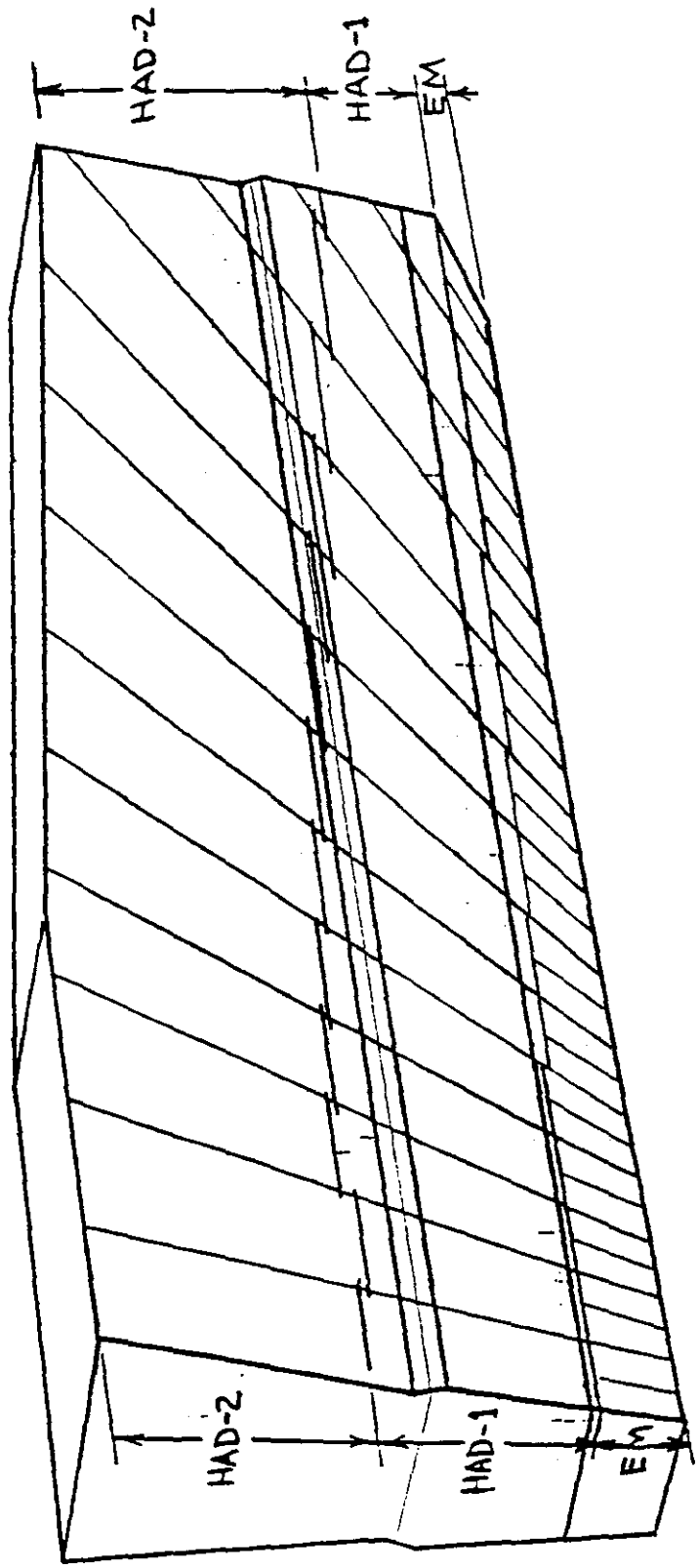
4) A new baseline is needed to optimize cost and performance.

FERMILAB
ENGINEERING NOTE

SECTION	PROJECT	SERIAL-CATEGORY	PAGE

SUBJECT: SDC BARREL 1/32 INNIE WEDGE
3D SKETCH NOT TO SCALE

NAME: H. FULTON
DATE: 31 JUL 92
REVISION DATE:



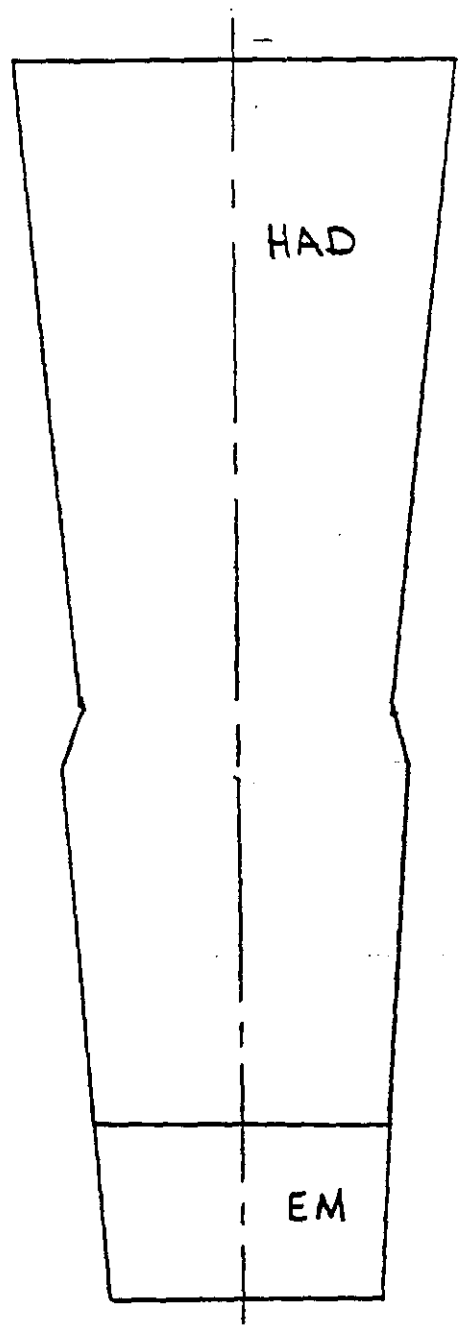
SDC BARREL INNIE 1/32 WEDGE

FERMILAB
ENGINEERING NOTE

SECTION	PROJECT	SERIAL-CATEGORY	PAGE

SUBJECT: INNIE 1/32 BARREL WEDGE AT LOW ETA
SKETCH NOT TO SCALE

NAME: H. FULTON
DATE: 31 JUL 92
REVISION DATE:



INNIE 1/32 BARREL WEDGE
AT LOW ETA

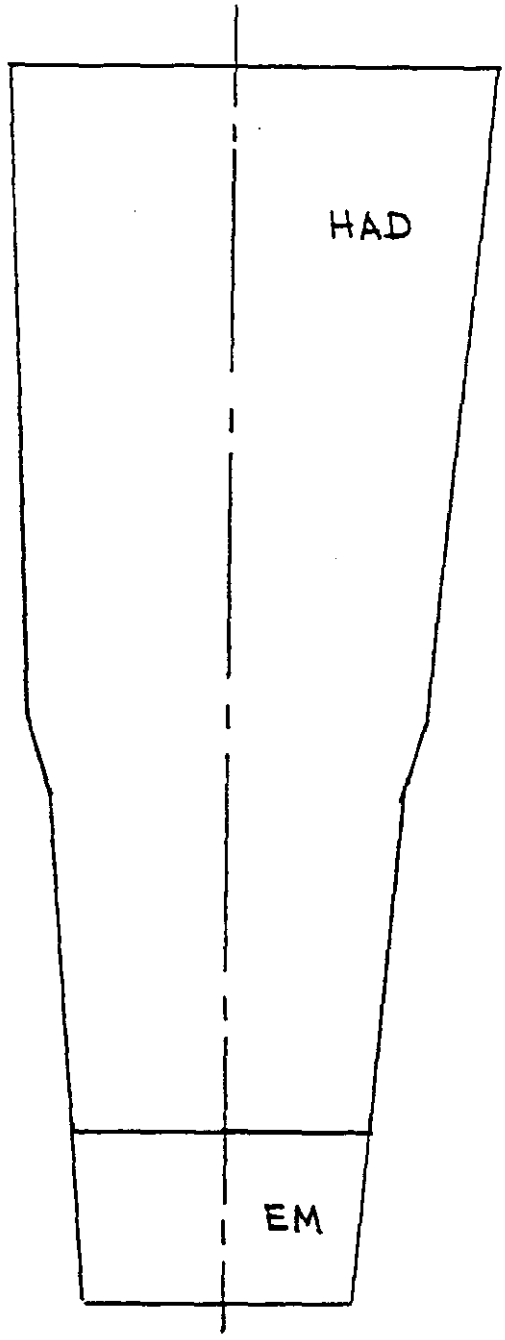
550198

FERMILAB
ENGINEERING NOTE

SECTION	PROJECT	SERIAL-CATEGORY	PAGE

SUBJECT: OUTIE 1/32 BARREL WEDGE AT LOW ETA
SKETCH NOT TO SCALE

NAME: H. FULTON
DATE: 31 JUL 92
REVISION DATE:



OUTIE 1/32 BARREL WEDGE
AT LOW ETA

550198

Endcap Review and Design Selection

Objective

Set up a committee to review the baseline and alternative endcap designs.

Charge to committee to recommend a final design based on cost and performance

Baseline

EM - Cast lead wedges

HAD - Steel wedges/monolithic endplug

Options

EM - Stacked lead

HAD - Monolithic steel with/without endplug

Goals

Review committee selection - Sept. 1

Review - Nov. 16

Recommendation to Technical Board - Dec. 1

Prototype Status and Plans

1) Fiber routing model (*Trojan Horse*)

2) Preproduction prototype

   - Design
   - Instrumentation
   - Absorber/radiator procurement
   - Beam test fixture
   - Schedule
   - Cost

Wooden Model (*Trojan Horse*)

Objectives

Fiber routing studies

Develop fiber dressing and attachment schemes

Cookie facing and potting on fiber bundles

PMT mounting

Electronics crate mounting

Light flasher and source driver mounting

Develop tooling for module assembly

Configuration

Baseline (1/32 wedge)

"Instrument" a few towers at low and high eta

EM (ANL)

Shower max (Saclay)

Had (Fermilab)

Schedule

First phase Aug. 21

Continuing test bed for assembly studies

Wooden Model Responsibilities

Model Task Manager - John Carson

Hadron Absorber Design - Larry Bartoszek

EM Radiator Design - Norm Hill

Shower Max Design - Dick Hubbard

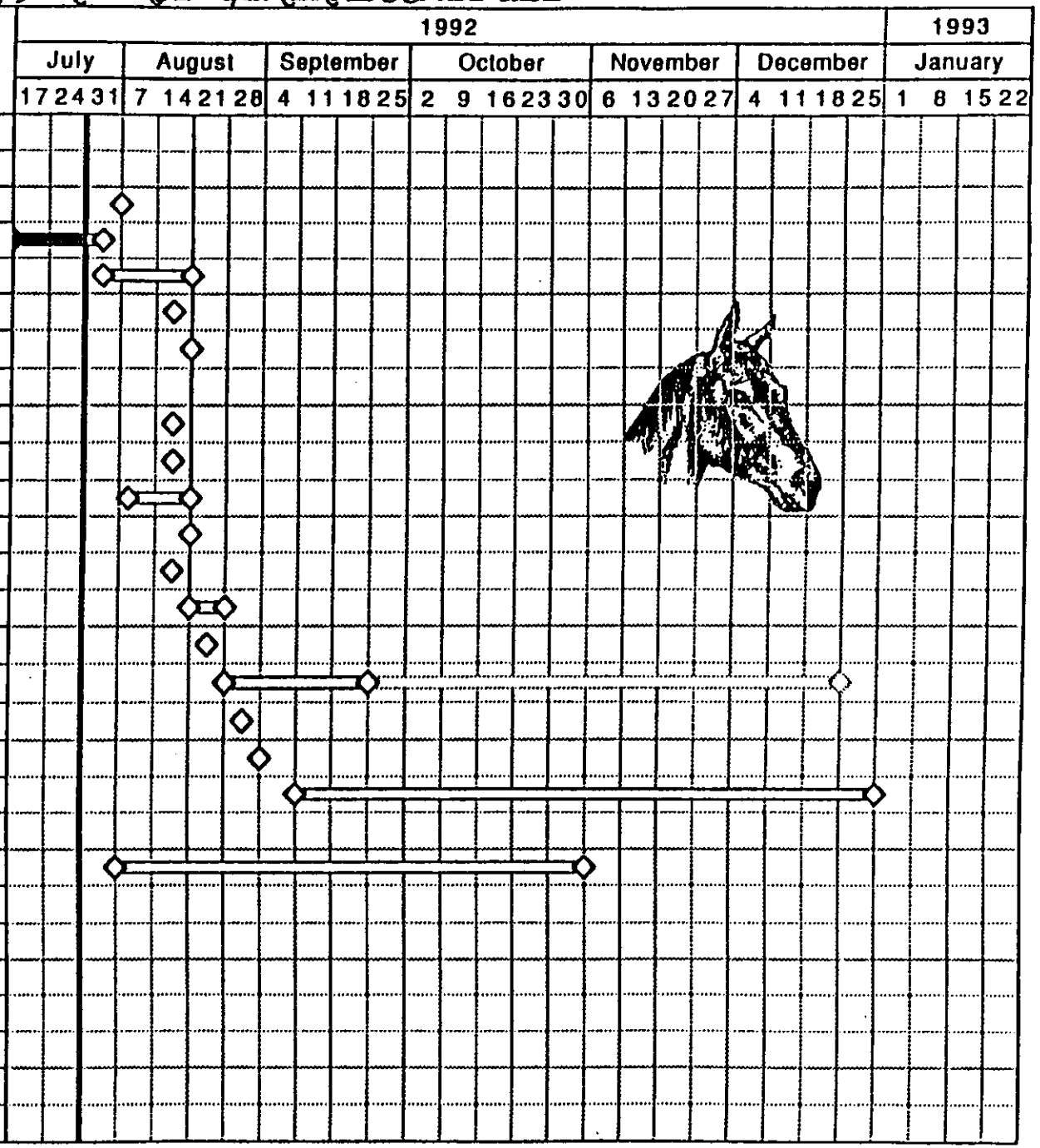
Integration - Jim Missig

Fiber Routing Task Force

- Larry Bartoszek
- John Carson
- Bill Foster
- Howard Fulton
- Steve Gourlay (chair)
- Norm Hill

TROJAN HORSE GENERAL SCHEDULE

T J GARDNER
ORIG. JULY 20, 1992
REV. JULY 23, 1992



Friday, July 24, 1992

Preproduction Prototype

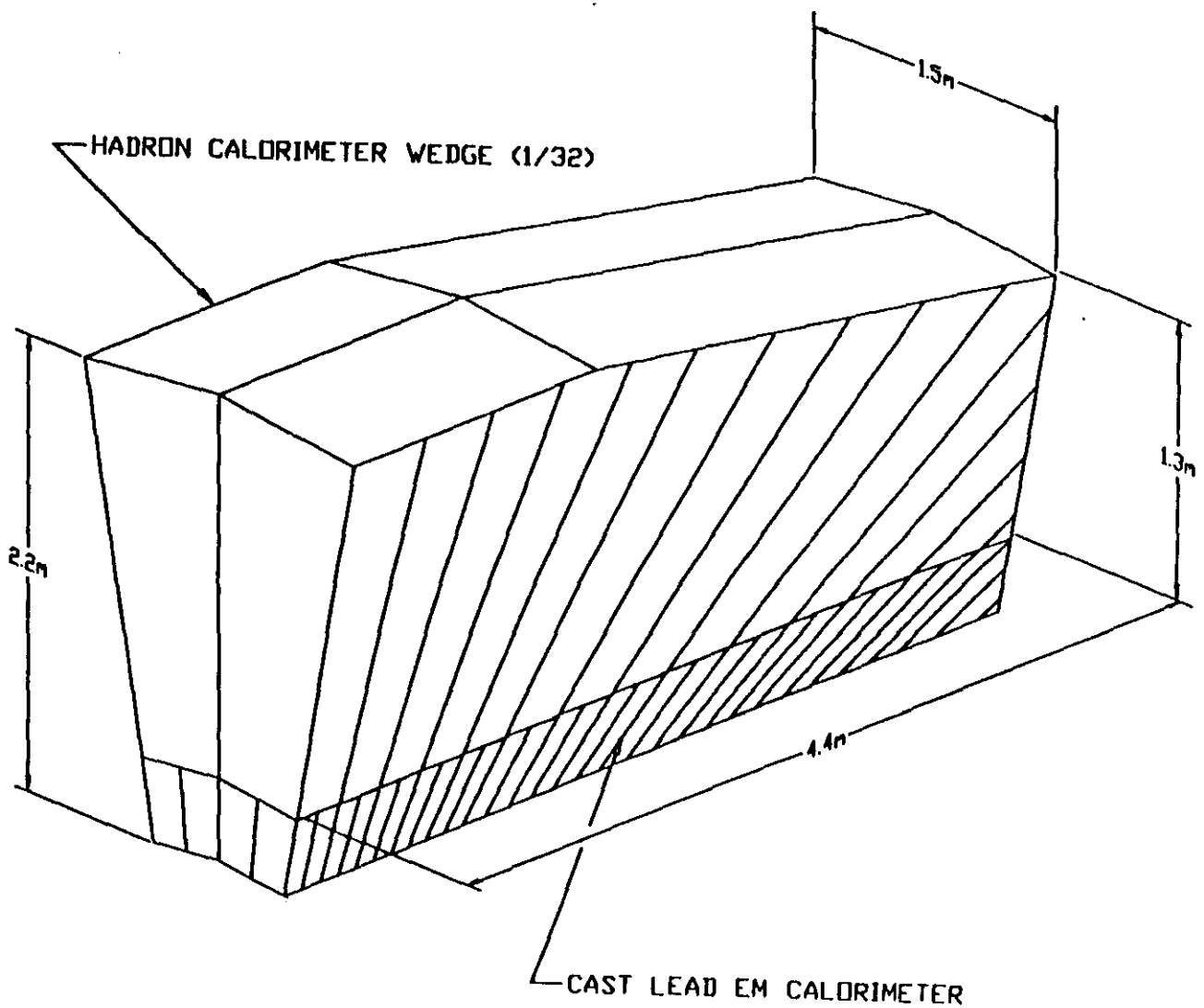
Objectives

- Promote design choices
- Focus design effort
- Establish collaborative infrastructure
- Verify mechanical design
- Develop manufacturing and assembly methods
- Refine cost and schedule
- Very Performance

Configuration

- Two full (1/32) wedges
- EM and HAD instrument at mid eta
- EM instrumented at high eta

PREPRODUCTION PROTOTYPE WEDGE



Preparation for DOE Review

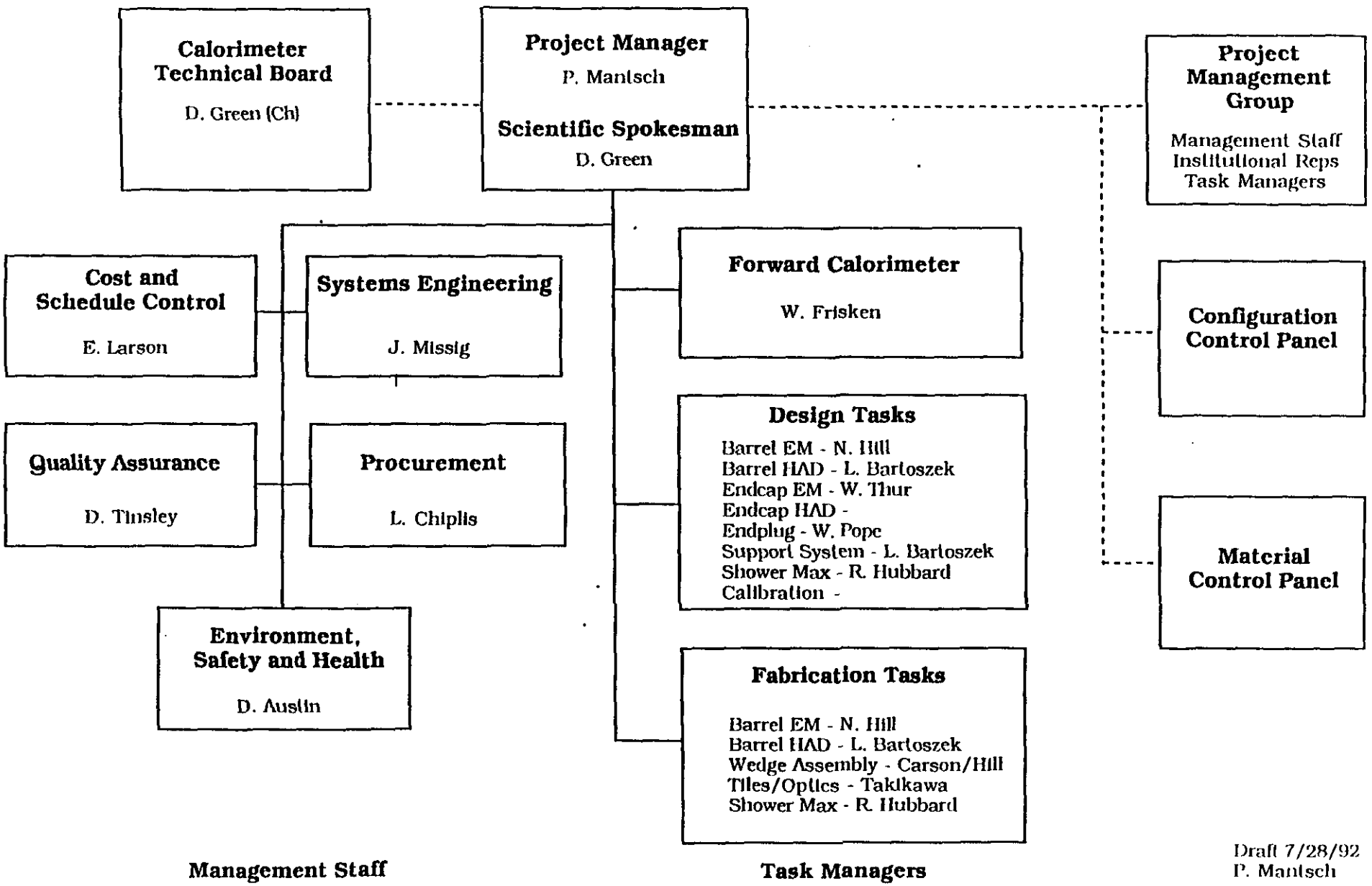
1) Organisation
- Task Definition
- Task Managers.

2) WBS
Needs Review by Task Managers
- Some inconsistencies
- Improved Facilities Element
- "Defensible"

3) Cost
Needs Review by Task Managers
- Single biggest issue in Barrel Steel
- 11 companies to bid on prototype wedge (out ~ Sept 1)
- Calibration System can have a big impact.

4) Schedule
Needs Review by Task Managers
- done in a mathematically defensible way wrt. WBS

SDC Calorimeter Organization



Draft 7/28/92
P. Mantsch

Steering Committee

Agenda Tuesday Aug. 4, 12:15

EM design review

DOE review - assignment of speakers

Organization

Calibration task manager

Other task managers

Dogleg question

Endcap design decision

Surface facility review

FY93 budget request and priorities

WBS estimate changes

Comprehensive mailing list

Teleconference for Steering committee?

Institution by Task < Engineers / Physicists

Calorimeter Tasks and Managers

Barrel HAD

Barrel EM

Endcap EM

Endcap HAD

Tile and Optics Design

Tile and Optics Fabrication

Photomultiplier Tubes

Shower Max

Barrel Module Assembly

Endcap Assembly

Support System

Final Assembly

Prototype

R&D

FCAL

Shower Max Photo-detectors.

Calibration.

Electronics liason.

DOE Speaker List
(Draft)

Design Summary	
Barrel EM & HAD	
Endcap & Options	
Optical System Design & Manufacturing	Takikawa
Shower Maximum Detector	Hubbard
Calibration System	
Prototype Plan	
Management Plan	Mantsch
Cost	Larson
Schedule	[redacted]
Forward Calorimeter & Options	Frisken