GEM TN-92-115

Collaboration Council Meeting - SSCL

June 4, 1992

Abstract:

Agenda, attendees, and transparencies of the GEM Collaboration Council Meeting held at the SSC Laboratory on June 4, 1992. Agenda items are: Report from Spokesmen; Report of Progress on Full GEANT Simulation; GEM Baseline I and Evolution to Baseline II; GEM Physics Simulations; GEM Organization Committee Report; GEM Costing; Report on GEM Magnet; GEM News; Calorimeter Report; Muon Report; Central Tracker Report; and Electronics Report.

GEM Collaboration Council Meeting
June 4, 1992
Revised Agenda

Report from Spokesmen (B. Barish/B. Willis)
Report of Progress on Full GEANT Simulation (K. McFarlane)
GEM Baseline I and Evolution to Baseline II (M. Marx)
GEM Physics Simulations (F. Paige/K. Lane)
GEM Organization Committee Report (C. Baltay)
GEM Costing (G. Sanders)
Report on GEM Magnet (R. Stroynowski)
GEM News (I. Sheer)

LUNCH

Calorimetry Report
- M. Seman
- Y. Kamyshkov
- L. Sulak
- H. Newman
- R. Zhu

Muon Report (F. Taylor)
Central Tracker Report (C. Baltay)
Electronics Report(D. Marlow/M. Shaevitz)

GEM - JUNE 4, 1992

PARTICIPANTS LIST

LAST NAME	FIRST NAME	AFFILIATION
Allen	Charles C.	University of Texas at Austin
Barish	Barry C.	California Inst. of Technology
Bower	Chuck	Indiana University
Brau	James E.	University of Oregon
Bromberg	Carl	Michigan State University
Bugg	William M.	University of Tennessee
Chargin	Anthony K.	Lawrence Livermore National Laboratory
Cleland	Wilfred E.	University of Pittsburgh
Cohn	Hans O.	Oak Ridge National Laboratory
Kamyshkov	Yuri	Inst. for Theor. and Exper. Physics, (ITEP)
Korytov	Andrey	Massachusetts Institute of Technology
Lane	Kenneth D.	Boston University
Lee	David M.	Los Alamos National Laboratory
Lin	Guey	Academia Sinica
Marlow	Daniel	Princeton University
McNeil	Roger	Louisiana State University
Mufson	Stuart	Indiana University
Newman	Harvey B.	California Inst. of Technology
Osborne	Louis S.	Massachusetts Institute of Technology
Polychronakos	Venetios A.	Brookhaven National Laboratory
Prokofiev	O. E.	Brookhaven National Laboratory
Reid	Robert	Los Alamos National Laboratory
Reid	Robert	Draper Laboratory
Reidy	James J.	University of Mississippi

LAST NAME	FIRST NAME	AFFILIATION
Seman	Michael	Columbia University
Shaevitz	Michael	Columbia University
Shi	Xiaorong	California Inst. of Technology
Stroynowski	Ryszard	Southern Methodist University
Sulak	Lawrence R.	Boston University
Taylor	Frank E.	Massachusetts Institute of Technology
Tcherniatin	Valeri	Moscow Physics Engineering Institute
Teng	Ping-Kun	Academia Sinica
Todd	Richard A.	Oak Ridge National Laboratory
Vogel	Helmut	Carnegie-Mellon University
Wang	Ming-Jer	Academia Sinica
Webb	Robert C.	Texas A&M University
Willis	William	Columbia University
Wuest	Craig R.	Lawrence Livermore National Laboratory
Yanagisawa	Chiaki	State Univ. of New York at Stony Brook
Zhu	Ren-yuan	California Inst. of Technology

PARTICIPANTS LISTING

LAST NAME	FIRST NAME	INSTITUTION
DiGiacomo	Nicholas Joseph	Martin Marietta Astronautics Group

LAST NAME	FIRST NAME	INSTITUTION
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Bonushkin	Yuri	SSC Laboratory
Dingus	Peter	SSC Laboratory
Fissiak	Iouri	SSC Laboratory
Guthrie	Richard	SSC Laboratory
Marx	Mike	SSC Laboratory
McFarlane	Kenneth	SSC Laboratory
Mitselmakher	Gena	SSC Laboratory
Morgan	Kate	SSC Laboratory
Paige	Frank	SSC Laboratory
Sanders	Gary	SSC Laboratory
Sarantsev	Viktor	SSC Laboratory
Sheer	Irwin	SSC Laboratory
Stocker	Frank	SSC Laboratory
Tchistilin	Victor	SSC Laboratory
Vaniachine	Alexandre	SSC Laboratory
Villasenor	Luis	SSC Laboratory
Wisniewski	Bill	SSC Laboratory
Woolley	Ronn	SSC Laboratory
Yost	George P.	SSC Laboratory
Zhukov	Valeri	SSC Laboratory

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Presentation by:

B. Barish

BARLIH

Progress

(May)

* TNRLC grants $1.985M R+D funds to GEM Projects

* MAGNET Acquisition Plan signed by Schwitters + Submitted to DoE

* Requested move coil winding bldg IR8 → IR5

* Requested moving Quads back from IR Hall

* CHINA

* Baseline I Budgets Reductions

* Baseline I ⇒ Baseline II

Superconducting Super Collider Laboratory
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Physics Research Division
GEM Project Office

Memorandum ***92 6424 E P 0001***

To: Harvey Lynch and Jon Ives
From: Gary Sanders - GEM Project Manager GS
Subject: The GEM Coil Winding Building
Date: June 1, 1992

Due to the fact that the Gem Magnet is on the critical path of the experiment and the completion of the SSC, the on-site facilities for the magnet construction and assembly are required at a very early date.

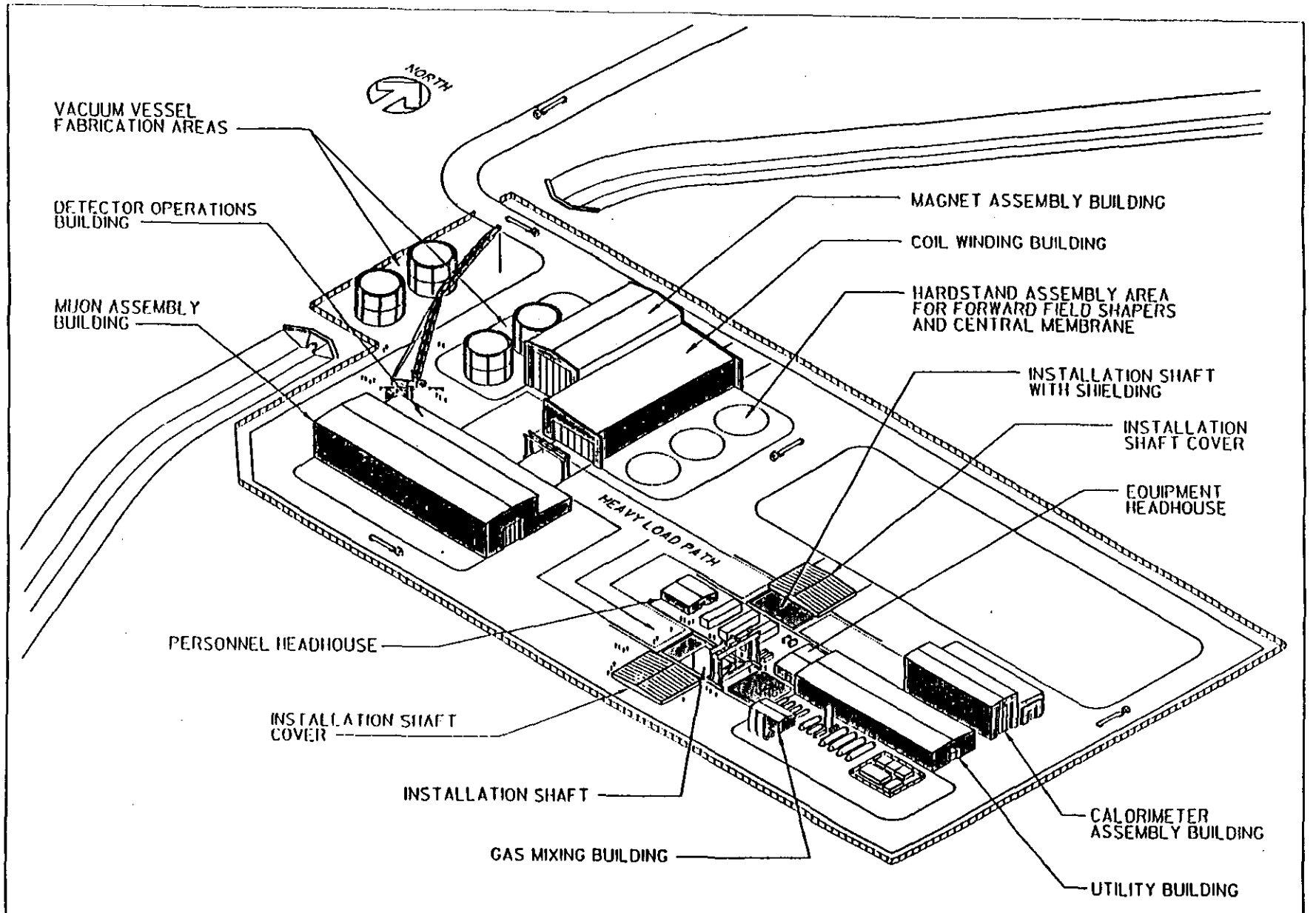
The beneficial occupancy of the coil winding building is required for February, 1994 and the information available at that time indicated that the only solution was to place this building at IR8. This was due to the fact that the access to both IR5 and IR8 was foreseen commencing from the north and that the exploitation of the IR5 site would also involve more preparation than IR8 because of the wetlands present in that area.

An alternative solution for access has now been proposed using the upgrading of Ebenezer Road and Tammy Lane to enter the site, which would enable the surface equipment of the contractor to be brought in at an early date to start the necessary preparations. Since these roads are off the SSC site area, the TRLNC have been responsible for the negotiations of these road improvements. The schedule must be maintained, within a month or so, thus permitting the required access in order to meet the Coil Winding Building BOD.

If the Coil Winding Building were to remain at IR8 then the 24 transportations of the finished wound magnet coils, approximately 20m diameter, from IR8 to IR5 would impose special requirements on the road and bridges between those two sites.

With these facts we request that you pursue the option of the Coil Winding Building being placed at IR5, as shown in the attached preliminary drawing. This solution we feel will considerably improve the GEM magnet manufacturing and assembly process and, at the same time, meet the schedule requirements. I would appreciate any comments you may have at your earliest convenience and would also appreciate receiving confirmation of a modified layout showing these changes in the near future.

Copies to: Ed Crumpley
Holly Durden
Mike Harris
Tom Prosapio
Bob Richardson
Gary Sanders
Bill Willis



IR-5 SITE

TVP/kh/hh - 5/20/92 - GC000015T.BW

DATES

July 2 Coll. Council Mtgs (Before PAC July 11-12)

Aug 5 Coll Council Mtgs (Before Dallas Mtg)

Sept 3 Coll Council Mtg

Oct 8 } Coll Council PROPOSED
Nov 5 }
Dec 3 }

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Presentation by:

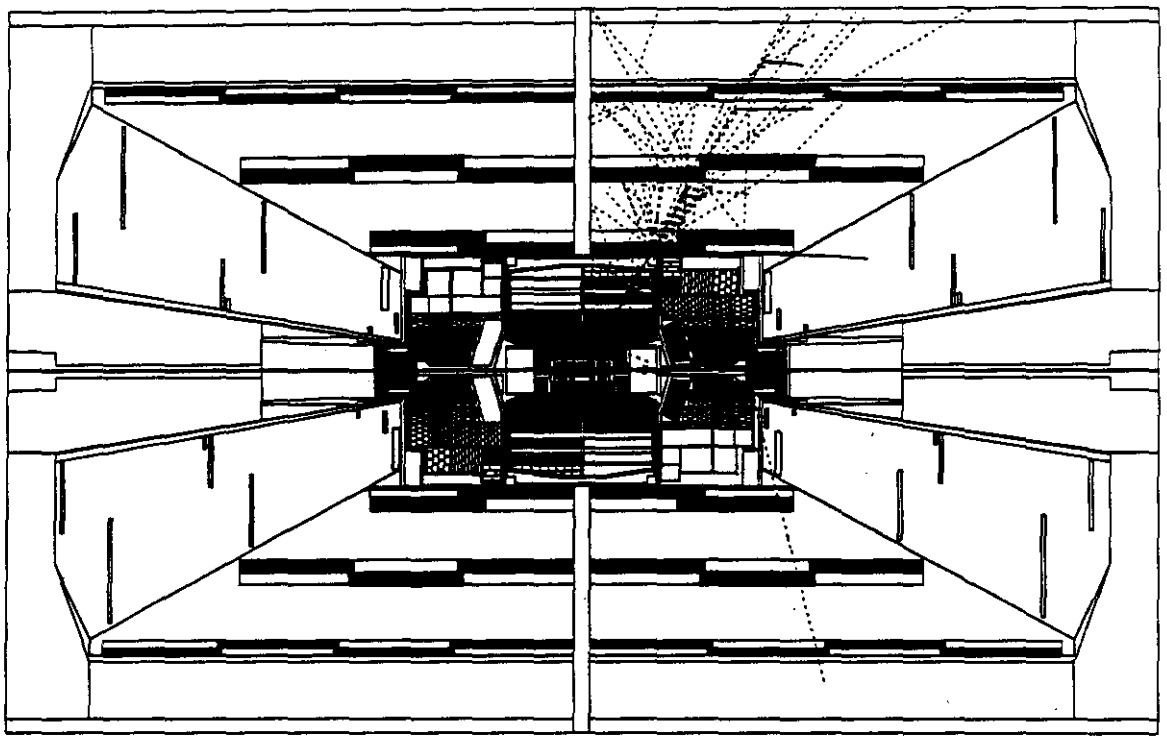
K. McFarlane

GEM

McFarlane

Full GEANT Geometry - Baseline I (Yu. Fisyak)

Single muon (100 keV cutoff for γ)



Full GEANT Simulation Workshop (date TBA)

~July

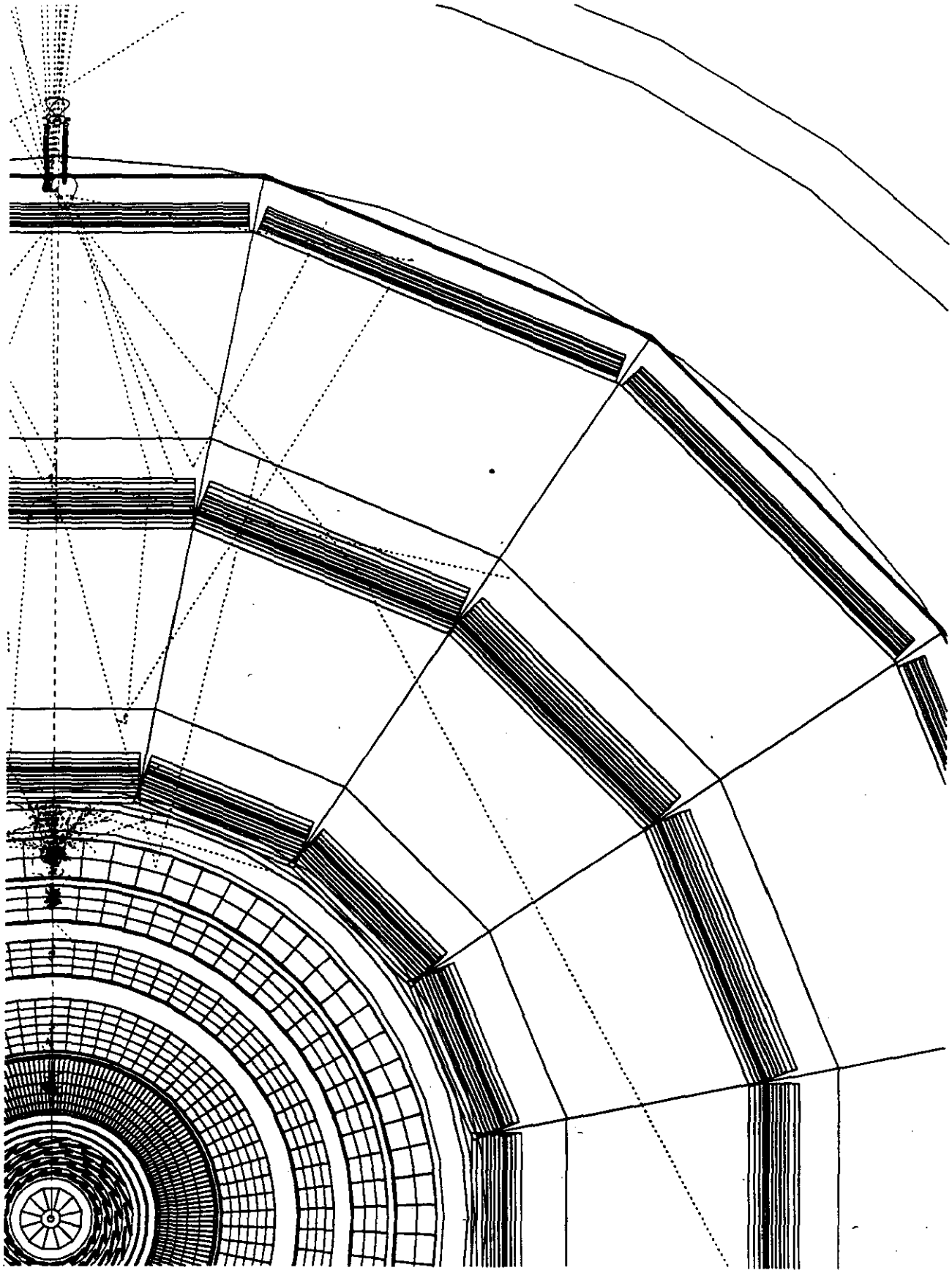
Baseline II geometry + hits
digitization
] each sub-detector

pileup

pattern recognition

trigger

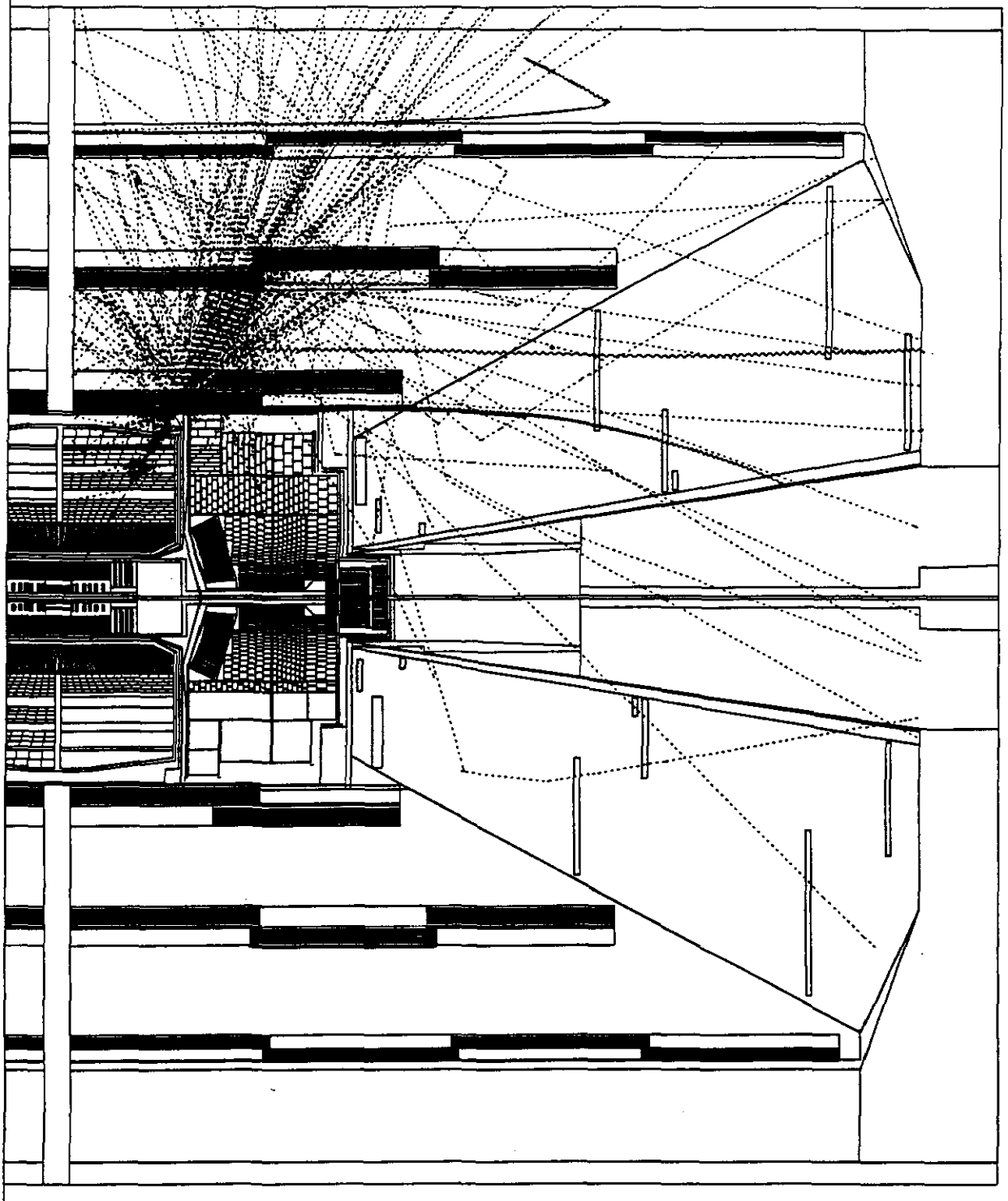
YEM - Full YEM Geometry - Baseline 1 (M. Fisyak)



GFM

Full GEANT Geometry of Baseline I (Yu. Fisyak)

muon (100 keV threshold for γ)



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Presentation by:

M. Marx

Baseline 2

6/4/92

Baseline I 4/23/92

Loose Compendium of Data

First Evaluations

Cost + Performance

Baseline 2

Iterate Detector

Coherent/Improve Format

Submission to PAC

(Last submission was LOI!)

Suggestions for IMprovement of Baseline 1
M. Marx
June 2, 1992

We intend to upgrade and improve the baseline 1 document for the dual purposes of providing more coherent information to the collaboration and to use as a major part of our submission to the PAC in July. For the former we request help from the subsystems in updating the information, improving the format, adding material where needed, and weeding out extraneous material. For the latter, we intend to beef up the textual material as a guide for the PAC to our current design status. It is worthwhile to recall that the last submission to the PAC was our LOI in December - this had no FFS, a completely different tracker, no mobile magnet, etc...

We list below requested changes in the baseline. First general changes and additions are listed, and then subsystem specific comments are indicated. Further improvements suggested by each susbsystem are welcomed, and suggestions of others will be forwarded. You are urged to look critically at all subsystems - this volume is intended to be read and used by non-experts as well as afficionados!

General Comments:

1 We will add 2 new sections on Radiation Levels/Activation and on SSC Test Beam Facilities and Plans.

2 All technical drawings should conform to standard engineering practices.

3. All drawings, plots, and illustrations should be provided with clear captions, if at all possible, directly on the figure.

4. All subsystems should revisit the introductory texts from the point of view of explanation to the PAC of changes from the LOI (and rationale), and the current staus of the design and the outstanding issues. **These should be submitted within 1 week (due June 12).**

5 All subsystems should re-examine the statements of physics and engineering specifications which preface the sections. These should provide a clear statement of the highest level specifications, goals, purposes and constraints within which the design is proceeding.

6. All plots of performance calculations should reference existing or future GEM notes to provide the basis of the calculations. This includes resolutions, acceptance, efficiencies, etc.

7. All drawings showing more than one subsystem should show baseline versions of each system for consistency.
8. All systems should provide abbreviated lists of key milestones to augment the general GEM and facility milestones. **These are due by June 12.**
9. All submissions to the new baseline should be complete by June 25.

Specific System Comments:

Magnet and Field

- Check that Baseline is coinsistent with TDR

Tracker

- Fix consistency of calorimeter drawings
- Wire readout to stereo pads
- Material budgets for silicon and IPC - plots for all eta
- Drop cabling requirements

Calorimeter

- Legitimize new baseline
- Show module details - EM and Hadron
- Show plots of X0 and lambda vs eta,phi
- Resolution vs eta
- Acceptance for e,gamma

Muon

- Show technical details of technologies
- Show truss details for barrel and ends
- Fix table p 11-17
- Captions and Figures in Sec 4 don't match
- DEpth doesn't match calorimeter baseline
- Does energy loss include calorimeter measurements??
- Trigger plots hand drawn!!! General quality poor

Alignment

- Needs beef

Major Changes (EXEC recommend)

1) IPC anode wire dropped
stereo pad layers
cheaper + better

2) Muon Barrel
8 : 8 : 4 → 4 : 8 : 4
Cost + coherence with ends

3) Calorimeter Baseline
(still choose BaF vs L?)

Concerns
Accordion performance w/ LAr
Hadron Cost

Emphasize EM Performance
→ LKr EM
→ Requires hybrid → LAr Had
→ Scint
→ Cost suggests Cu/Scint
LKr + Cu SPACAL

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Presentation by:

F. Paige

F. Paige

Physics status:

$H \to \gamma\gamma$: New resolutions.

e ID looked at - no problem

Central tracker $\Leftrightarrow$ multiplicity?

$t\bar{t}H$: Done

$H \to ZZ^*$: e ID in endcap.

$t \to b \to \mu$ tag : $l^+ l^- \mu^\pm$ well along

$l^\pm \mu^\mp 3j$ - ?

e ID @ 10^{34} : Done

$\not{E}_T$: Forward cal looks OK, but no plots

LQ : Started

$Z' \to \mu\mu$: Nothing new

$Z' \to ee$: Done

Simulation Status

FAST Simulation

Parameterizations exist for all systems. Integration "in progress"

Code located in

~gemlib/hpx/fast//v1/....

Some simple examples, but not fully working system.

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Presentation by:

C. Baltay

GEM ORGANIZATION COMMITTEE

C. Baltay

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

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

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

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

Some Random thoughts and Questions

1. CO SPOKESMEN
   a) Term of office - lifetime? 3 years?
   b) How are they selected
      i) Vote by all members of Collaboration
      ii) Vote by Collaboration Council
      iii) Vote by Collaboration Council (Yes/No) on a single slate prepared by a Nominating Committee
         - 3 chosen by Collab Council
         - 3 " " Spokesmen
         - 2 " " SSC Lab
         - Non GEH members?
      iv) Some sort of Board of Trustees
      v) SSC Lab Director
      vi) Other?
2. Project Manager - same questions as above
3. Executive Committee
   Appointed by Spokesmen - 3 year terms?
   Contains Sub system leaders; O.K. by Collab. Council
4. Collaboration Council
   Selected by each institution
   Term as appropriate
5. Subsystem leaders
   Appointed by Spokesmen
   Approval by Collaboration Council?

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Presentation by:

R. Stroynowski

Stroynowski

GEM MAGNET ACQUISITION PLAN

Routing Sheet

PERSON	*TITLE*	*STATUS*	*SIGNATURE*
Richard Fischer	GEM Business Manager	Review	Richard L. Fischer
Gary Sanders	GEM Project Manager	Approval	
Bill Davis	GEM Subcontract Admin	Review	
Fred Gilman	Physics Associate Dir.	Approval	Frederick J. Gilman
Charlie Dan	SSCL Procurement	Review	
for George Provencher	SSCL Procurement Dir.	Approval	
Steve Brumley	SSCL Legal Counsel	Review	
Roy Schwitters	SSCL Director	Approval	

For the submittal of the GEM Detector Magnet Acquisition Plan to DOE on Friday, May 8, 1992

MAGNET UPDATE

DOCUMENT PREPARATIONS

1. "SUPLEMENTAL ENVIRONMENTAL ANALYSIS OF THE GEM MAGNET" IN-92-10

   Transmitted by Roy Schnitters to DOE on May 14.

2. "GEM MAGNET ACQUISITION PLAN" IN-92-9

   Reviewed and approved by the laboratory management. Transmitted by Roy Schnitters to DOE on May 14.

3. "GEM MAGNET REQUEST FOR PROPOSAL"
   - Draft exists. Will be sent for comments to industry on June 15.
   - Pending PAC approval will be sent out in August/September requesting bids due ~ end of September/October.
   - Pending DOE approval bid will be awarded in January 1993.

So far - no slips in schedule.

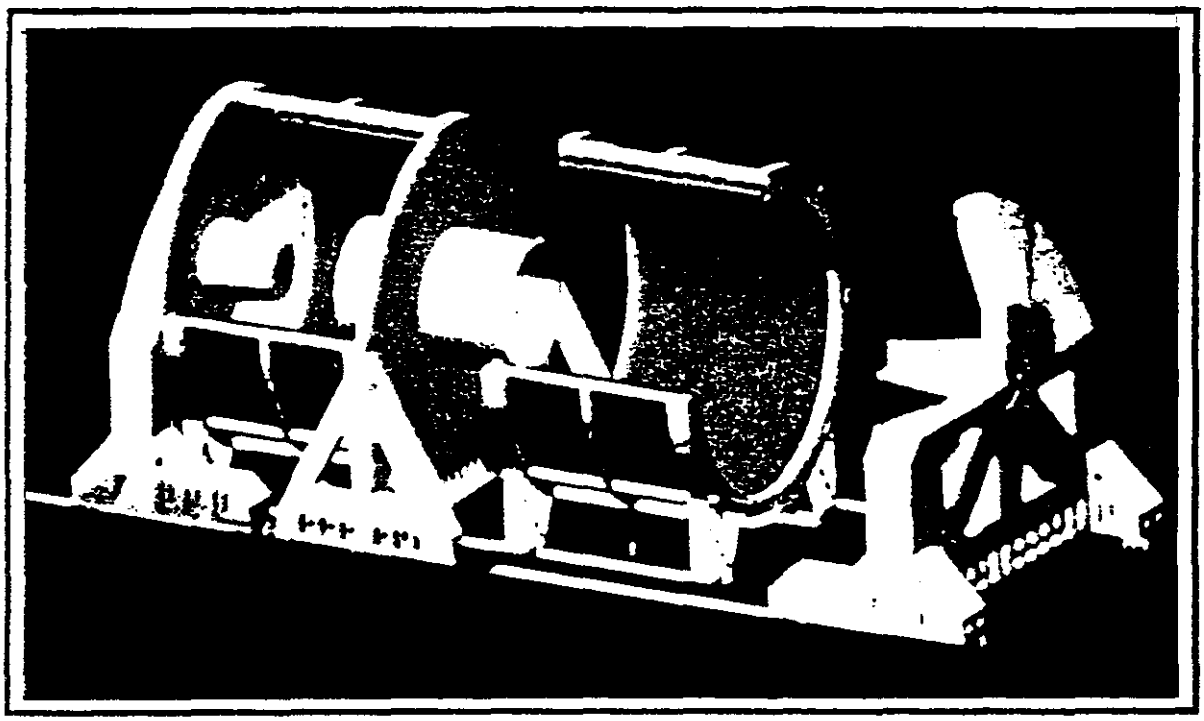
Plan: request industry to bid on coil construction. separate conductor, refrigeration system, forward field shapers and central support membrane as separate items.

the gem magnet

REQUEST FOR PROPOSAL

gem

magnet subsystem



Superconducting

4. "GEM MAGNET TECHNICAL DESIGN REPORT"
   1st draft exists.
   2nd draft due June 15.
   Will be submitted to PAC at the end of June.

5. "GEM Magnet Specifications"
   draft exists

6. "Conductor Acquisition Plan"
   in preparation

7. "Winding Development Plan"
   in preparation

8. "Magnet Cost Estimate"
   continuously updated, will be submitted to PAC

MAGNET MOBILITY QUESTION M. Harris

THE MAGNET MOBILITY POSSIBLIITES WERE DISCUSSED AT THE PREVIOUS EXECUTIVE MEETING AND AFTER VARIOUS INTERACTIONS WITH MAGNET, MUON, CALORIMETER AND TRACKER GROUPS THE FOLLOWING RECOMMENDATION IS PROPOSED AFTER RESTATING THE FACTS.

1. SINCE THE MAGNET HAS TO BE INSTALLED THERE WILL BE A NEED OF SUITABLE EQUIPMENT TO DISPLACE THE TWO HALF UNITS ALONG THE LENGTH OF THE HALL.

2. THE MAXIMUM COST DIFFERENCE BETWEEN A SOPHISTICATED SYSTEM TO CARRY OUT THIS MANEUVRE SEVERAL TIMES AS OPPOSED TO ONCE IS ESTIMATED AS $7.0M FINAL STUDY MAY SEE THIS FIGURE AS BEING LESS. Present estimate $\Delta \sim 2.5$ M

3. THE SEQUENCE OF THE BASELINE INSTALLATION SCHEME IS THAT THE MAGNET IS INSTALLED WITH THE CENTRAL MEMBRANE AND TESTED. THEN THE MAGNET CONNECTIONS ARE BROKEN AND THE HALF UNITS DISPLACED TO INSTALL THE CALORIMETER, THE BARREL MUON CHAMBERS AND THE TRACKER. THE MAGNET IS THEN CLOSED ONCE MORE AND THE ENDCAP MUON CHAMBERS ARE ADDED AND THE BEAM PIPE CONNECTED. THIS IMPLIES MOVABLE SERVICES FOR THE MUON BARREL.

4. IF THE CALORIMETER AND THE TRACKER COULD BE INSTALLED WITH THE TWO MAGNET HALF UNITS TOGETHER THEN THE MUON CHAMBERS COULD ALSO BE INSTALLED UNDER THE SAME CONDITIONS. THIS WOULD GIVE MINIMUM ACCESS DISTURBANCE DURING THE MAINTENANCE OF THE INNER CENTRAL REGION WHERE IT IS EXPECTED THAT THIS ACCESS WOULD BE REQUIRED EVERY YEAR AND THE ACCESS TO THE CALORIMETER IS ESTIMATED AS EVERY FIVE YEARS.

5. THIS IMPLIES NO MOVABLE SERVICES AND NO MAGNET DISCONNECTIONS.

Mobile Magnet costs

- We do save some installation cost, compared to fixed-magnet approach.

  Total estimate for fixed magnet is ~$3M.
  Savings guesstimate: as much as ~$1M.
  best guess ~$0.5M

  (We still must move to headhouse, lower, move to position, align, connect aux systems, etc., and now we have track inst/alignment)

- With integral calorimeter support (less weight on magnet) and grease pads, revised cost-increase guesstimate:

	min cost	max cost
track	0.25	1.0
drive system	0.5	1.5
grease pads	0.25	0.5
additional structure	0.5	1.0
	1.5	4.0

VG-GEM-92-006-3
2/13/92

M. Harris - present recommendations:

IN ORDER TO HAVE COMPLETE FLEXIBILITY IN THE FUTURE AND TO PERMIT THE STUDIES TO CONTINUE AT LEAST A FEW MORE MONTHS IT IS PROPOSED THAT THE MAGNET BE DESIGNED AS BEING MOBILE AND AT THE SAME TIME CONFIRMING THE COST DELTA BETWEEN A ONE TIME MOVEMENT AND SEVERAL MOVEMENTS. HOWEVER, THE DETECTOR DESIGN TO ELIMINATE THE POSSIBLE USE OF SUCH AN IMPORTANT INTERVENTION SHOULD BE CONTINUED WITH THE HIGHEST PRIORITY.

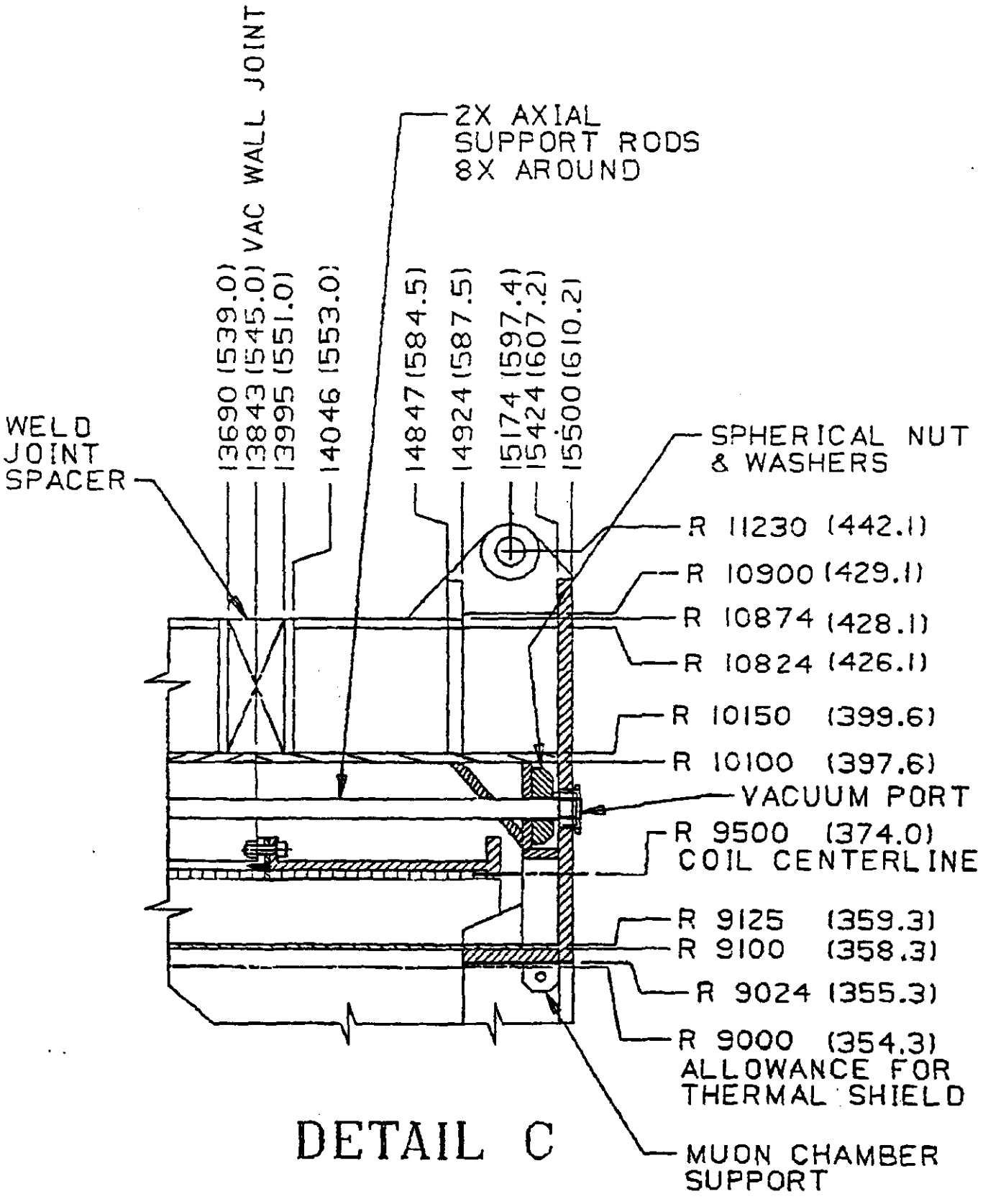
MAGNET DESIGN STATUS

- TECHNICAL DESIGN REPORT – REPRESENTS A CONSISTENT SNAPSHOT OF BASELINE 1 DESIGN. WORK CONTINUES ON DETAILED DESIGN OF EVERY ASPECT OF THE MAGNET AND MODIFICATIONS OF ELEMENTS DESCRIBED IN TDR SHOULD BE EXPECTED. OVERALL CONCEPTS RATHER FIRM EXCEPT THE QUESTION OF MOBILE VS NON-MOBILE COIL HALVES IS STILL PURSUED BY M. HARRIS. THIS QUESTION IS COUPLED TO "FINAL" CALORIMETERS AND MUON SYSTEMS DESIGN AND WILL BE RESOLVED IN NEXT FEW MONTH.

- CONDUCTOR R&D – INITIATED BY MIT-PFC IN COLLABORATION WITH INDUSTRY. WILL PRODUCE FEW HUNDRED METERS OF CONDUCTOR, WORK ON DEFINING QUALITY ASSURANCE CRITERIA AND PRODUCE SEVERAL JOINTS

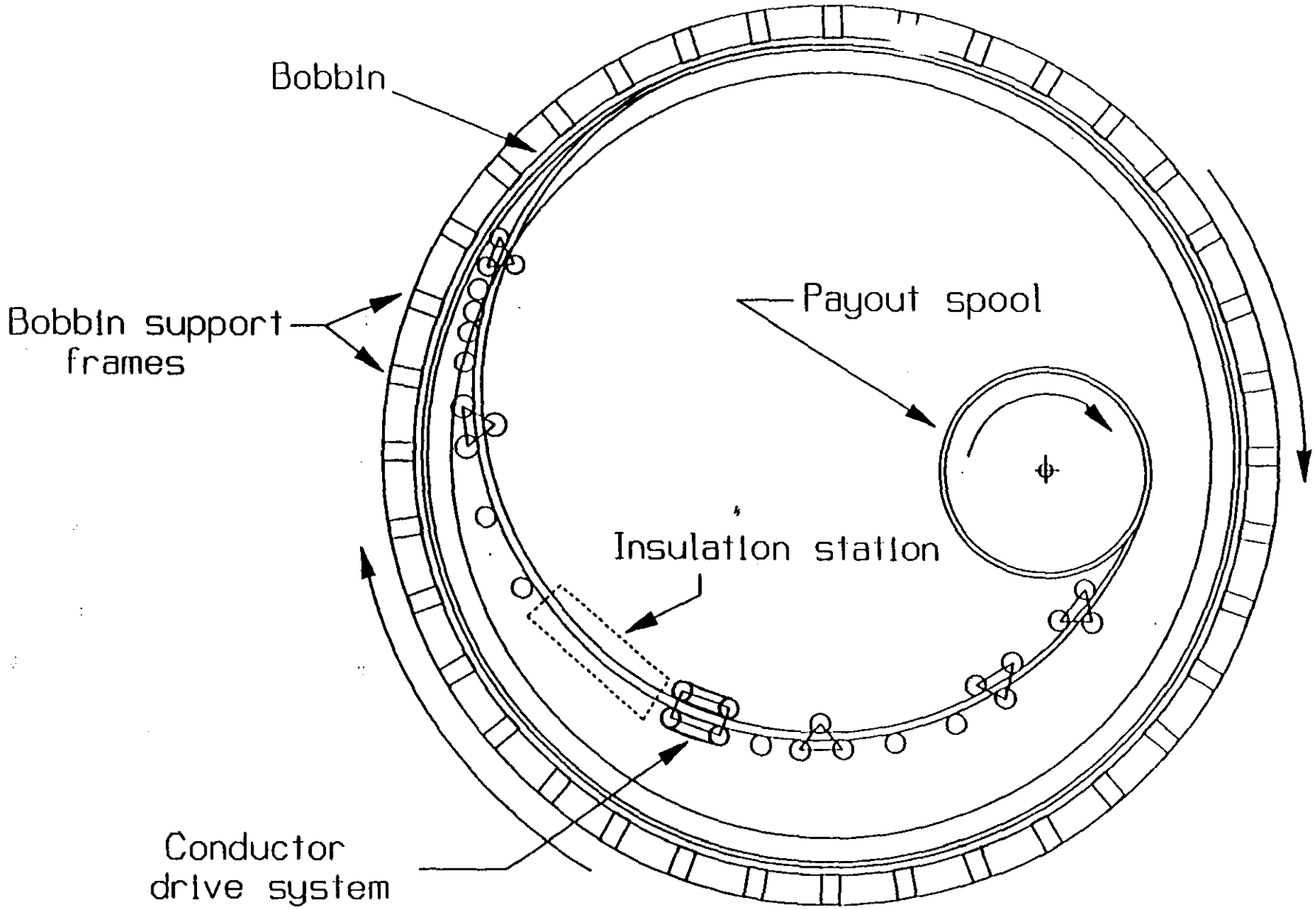
- WINDING R&D – OUTLINE PREPARED BY RUTHERFORD LABORATORY. IT WILL BE A MAJOR R&D ITEM IN 1982/1983.

- MAJOR AREAS OF CONCERN
  - FIELD MAPPING PLAN
  - ACCELERATOR INTERFACE



DETAIL C

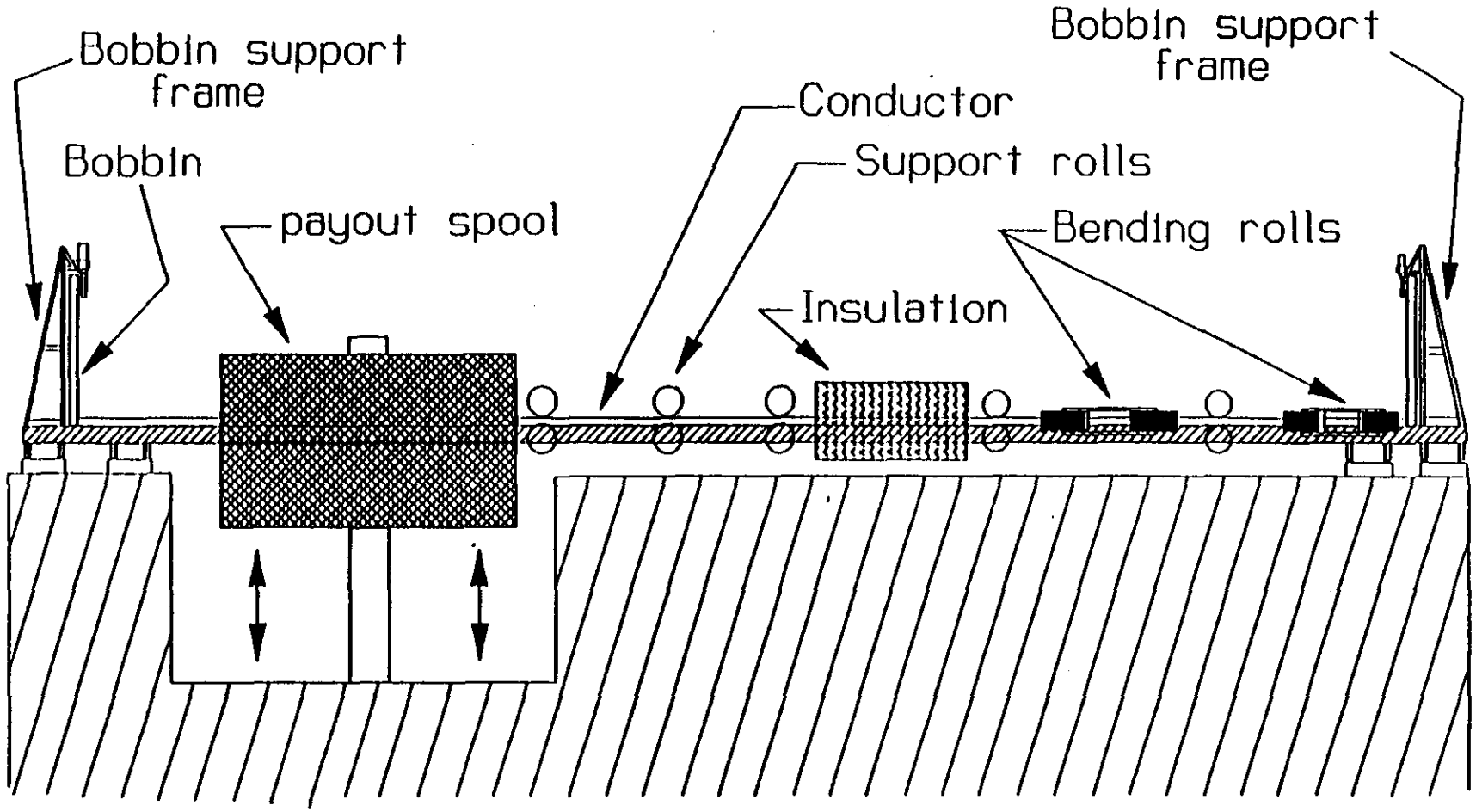
JUN- 1-92 MON 15:25 LLNL ARED FAX NO. 510 423 4143 P.05



Module Winding Concept

Figure 2.5.5.0

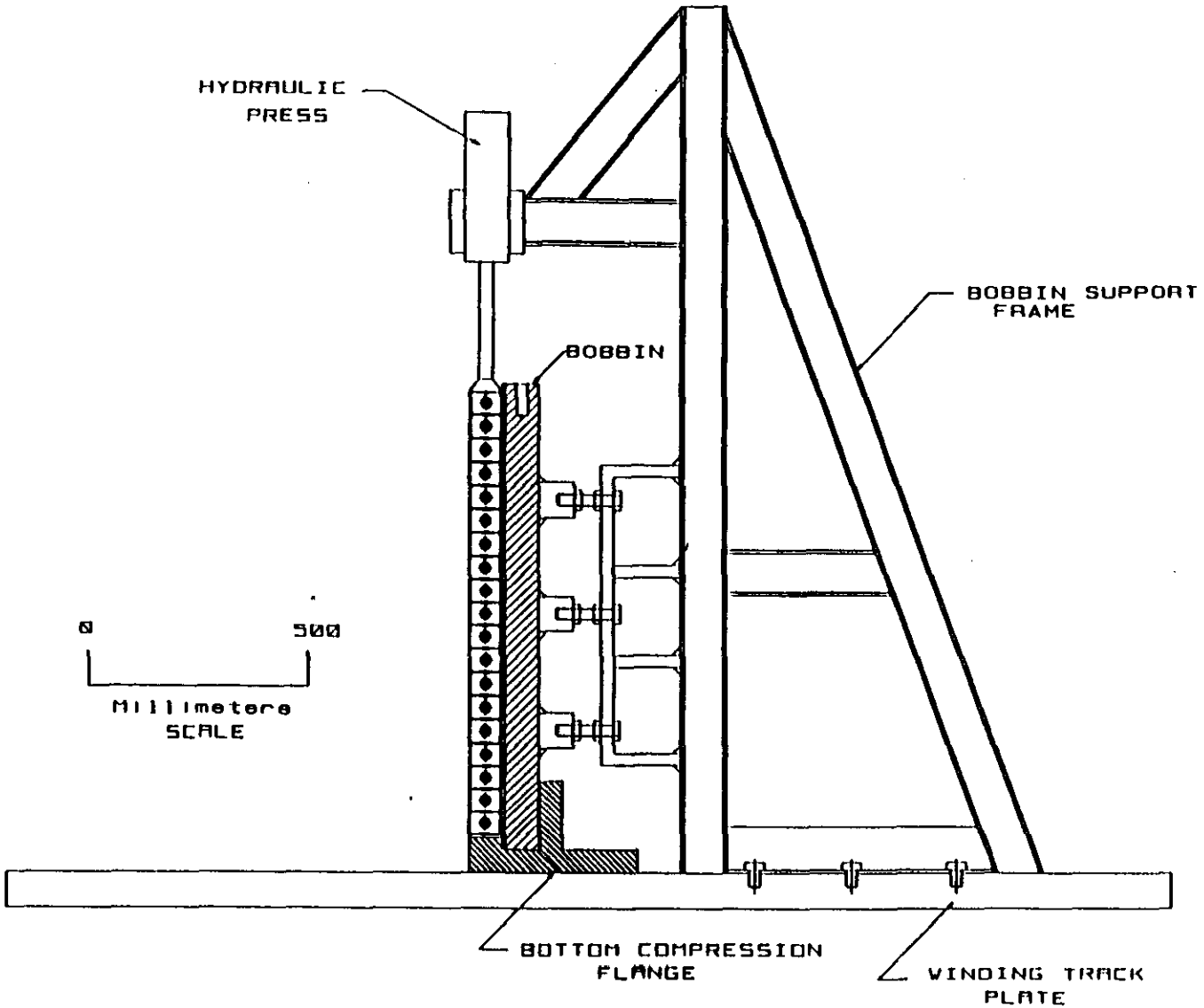
Fig 5-1



Module Winding Concept

Figure 2.5.5.1

Fig 5-18



WINDING/PRECOMPRESSION FIXTURES

FIGURE 2.5.5.2

Fig 5-19

gem

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Presentation by:

I. Sheer

I. Sheer

GEM news

- What we have now:
  - → gem_news on SSCVX1
    - ↓ must log on to SSCVX1
    - ↓ not used
  - → mailing lists
    - ↓ difficult to maintain (inaccurate)
    - ↓ inefficient
  - → ssc.pdsf.gem news group
    - ↓ only for pdsf related news
    - ↓ not used

GEM news

- What we need:

  → single GEM news system

  → collaboration wide (i.e. worldwide)

  → simple

  → customizable

  → creates permanent archive

  → uses existing public domain software

usenet can handle all of our news

usenet is worldwide

'rn', 'vnews', and dozens of other news readers are powerful customizable programs

all news will be permanently archived

these programs exist and are used by millions of people

many of these programs are free!

GEM news

- a proposal:

  → USENET ←

  start with single news group:
  i.e. ssc.gem.news

  later expand to many special interest groups: i.e. .online, .offline, ...

simple to use:

UNIX: check if news:
rn -c ssc.gem.news
read news:
rn -g ssc.gem.news

VMS: read news:
vnews ssc.gem.news

post by sending email to:

ssc.gem.news@ssc.gov
SMTP%"ssc.gem.news@ssc.gov"

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Presentation by:

M. Seman

M.C. SIMULATION STUDY OF GEM EM BARREL CALORIMETER WITH PROJECTIVE ACCORDION STRUCTURE

MICHAL SEMAN
COLUMBIA UNIVERSITY

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* AIM - OPTIMIZATION OF ACCORDION STRUCTURE FOR BARREL

  - START WITH CURRENT 'BASE LINE' DIMENSIONS

* GEANT 3.14 ENVIROMENT

  - SET_UP
  - OPTIMIZATION OF GEANT
  - PHI DENSITY OPTIMIZATION WITH 'GEANTINO SCAN'
  - PHI DENSITY OPTIMIZATION WITH 50 GeV SHOWERS

  (GEOMETRY CODE IS BEING MODIFIED BY M. LELTCHOUK FOR THE SIMILAR ENDCAP OPTIMIZATION)

* ENERGY RESOLUTION

  - ENERGY RESOLUTION IN THE RANGE (5-320 GEV)
  - LINEARITY OF CALORIMETER RESPONSE
  - THETA DEPENDENCE OF ENERGY RESOLUTION
  - ENERGY LEAKAGE AS FUNCTION OF IMPACT ENERGY
  - POSITION AND ANGULAR RESOLUTION

* MOST OF THE STUDY WAS DONE WITH <u>LIQUID KRYPTON</u> AS ACTIVE MEDIUM

  - ENERGY RESOLUTION FOR LIQUID ARGON FOR :
    - TWO STRUCTURES AT THETA = 90°
    - ONE STRUCRURE AT THETA = 45°

* INFLUENCE OF CHARGE COLLECTION AND PULSE SHAPING ON ENERGY RESOLUTION

CALORIMETER SET_UP

* FOR 7 x 7 TOWERS > 3000 POSITIONE VOLUMES

* GEANT CAN'T STANDARD WAY OPTIMIZE SEARCH OF THE VOLUMES

  - IT WILL SPEND MOST OF THE TIME IDENTIFIING IN WHICH VOLUME IS IT CURRENTLY AND WHERE TO STEP NEXT

  - OVER 20 min/GeV with 100 keV CUTS ON SGI

  - TABLE OF NEIGHBORN VOLUMES then 12-25 sec/GeV

  - VERIFICATION - RANDOM GENERATOR SEED NUMBER AFTER GENERATED EVENS HAVE TO BE THE SAME FOR BOTH SLOW AND FAST VERSIONS

* DEFINITIONS

  - MEAN GAP WIDTH
    - energy resolution (sampling ratio and frequency)
    - tower dimensions

  - STARTING ANGLE
    - local inhomogenities (number and magnitude)

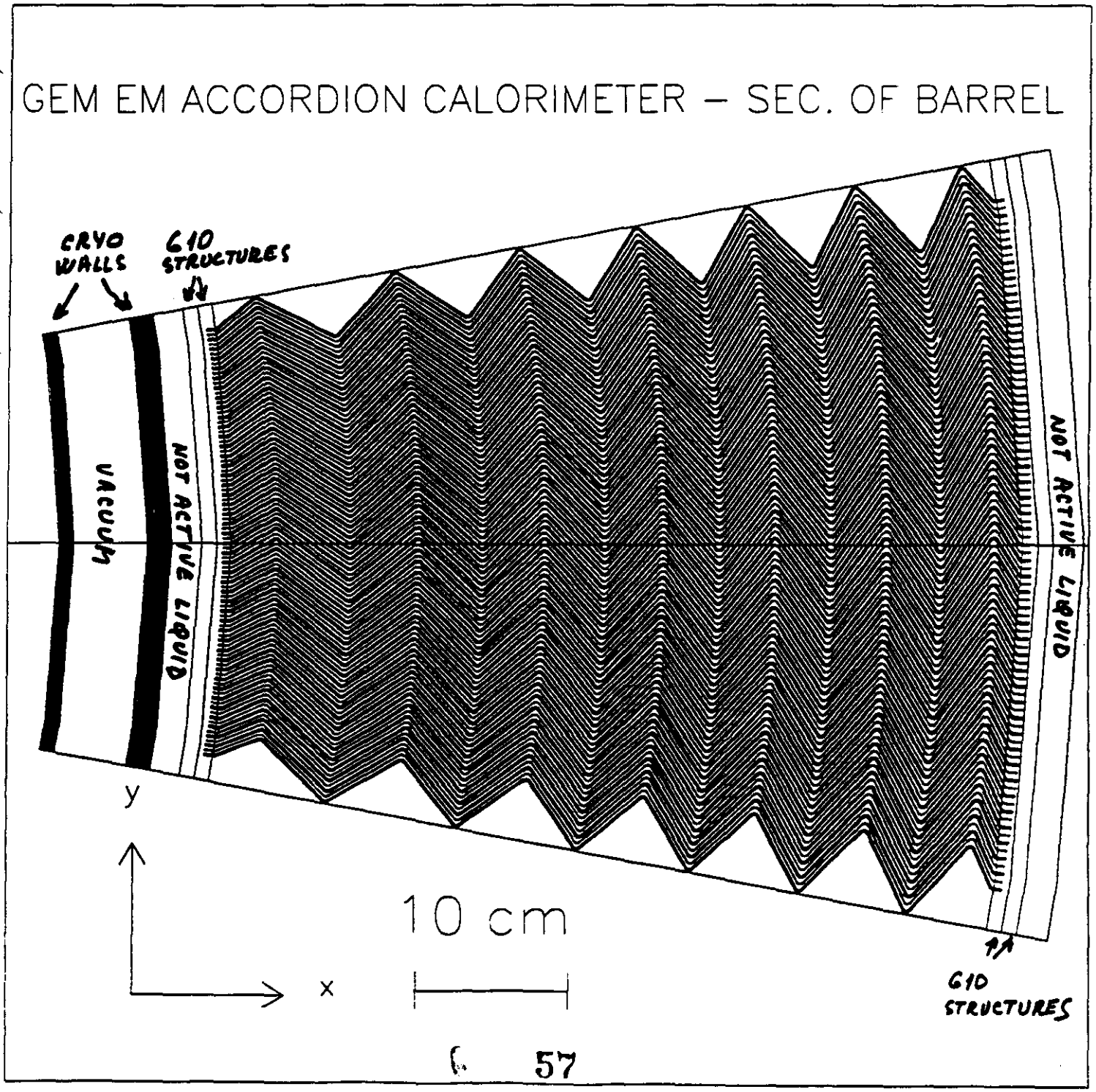
  - BETA/DELTA RATIO
    - energy resolution
    - position and angular resolution
    - isolation

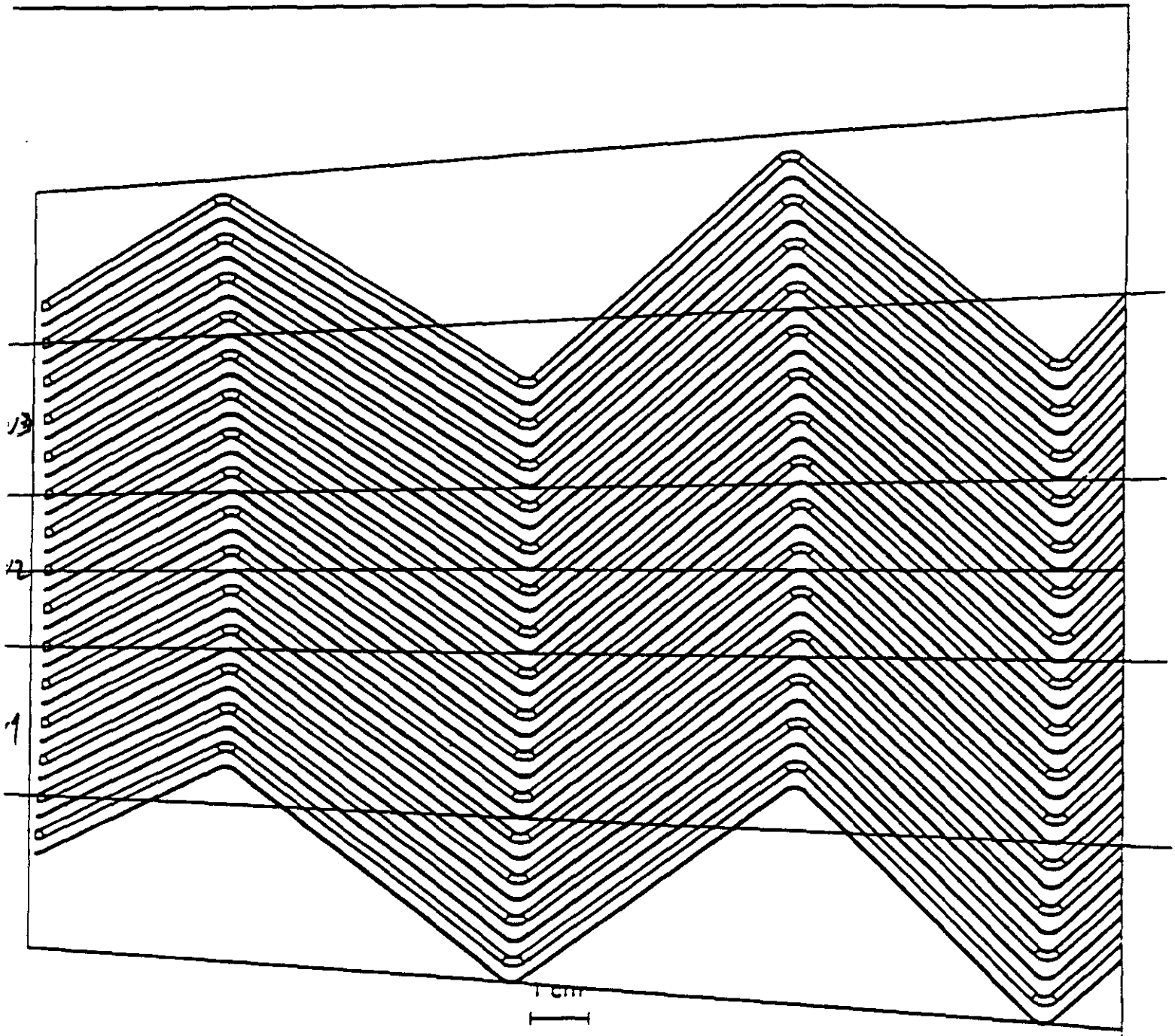
  - MEAN CORNER RADIUS
    - energy resolution

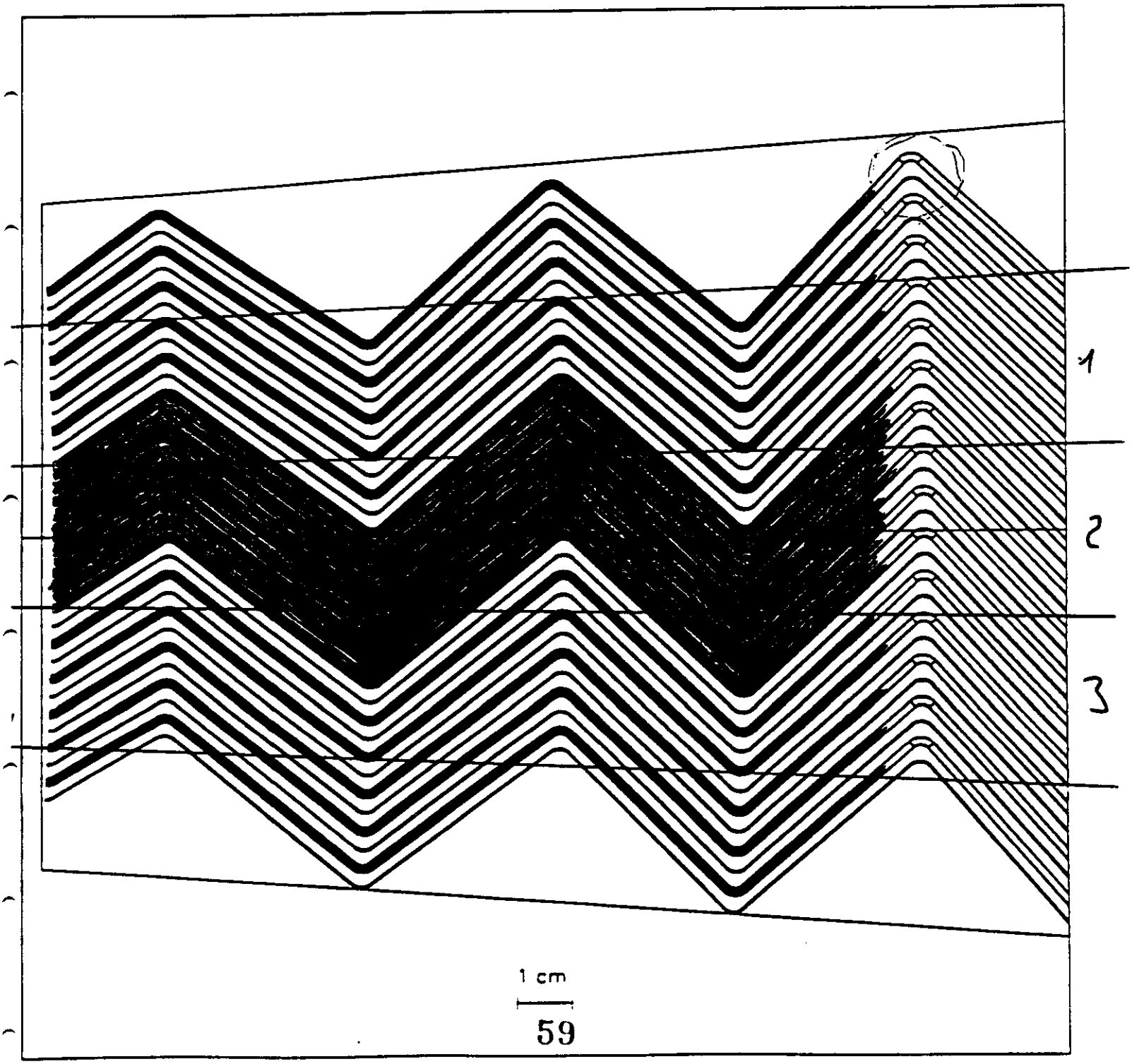
* STARTING CONSTRAINS

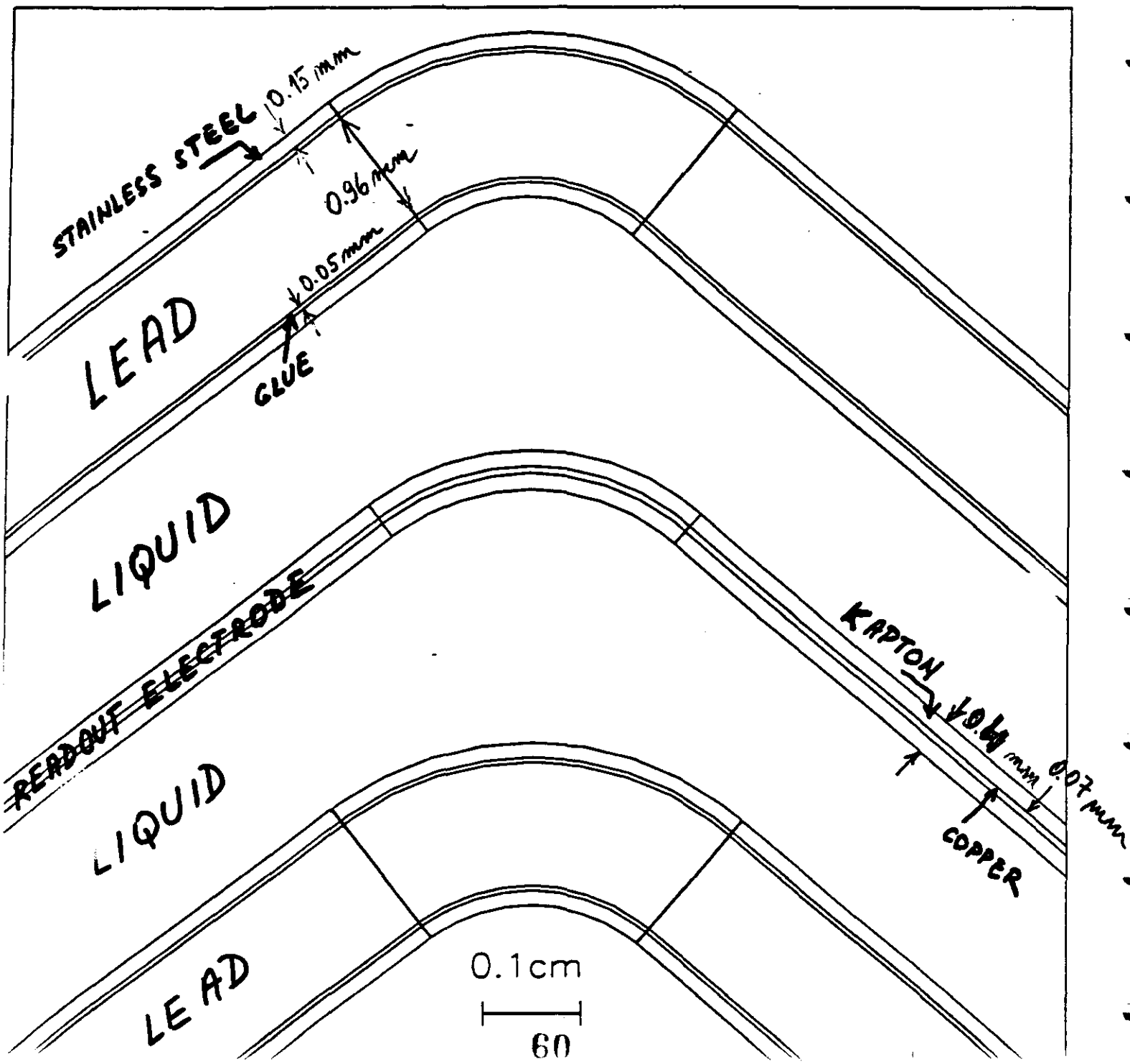
  - 52.1 cm AVAILABLE FOR ACTIVE CALORIMETER DEPTH
  - 25 X0 REQUIRED

* PHI DENSITY OPTIMIZATION WITH 'GEANTINO SCAN'
* PHI DENSITY OPTIMIZATION WITH 50 GeV SHOWERS


GEM EM ACCORDION CALORIMETER – SEC. OF BARREL
CRYO WALLS
G10 STRUCTURES
VACUUM
NOT ACTIVE LIQUID
NOT ACTIVE LIQUID
G10 STRUCTURES
y
x
10 cm


1 cm


1
2
3
1 cm


STAINLESS STEEL
0.15 mm
0.96 mm
0.05 mm
GLUE
LEAD
LIQUID
READOUT ELECTRODE
KAPTON
0.07 mm
COPPER
LIQUID
LEAD
0.1cm

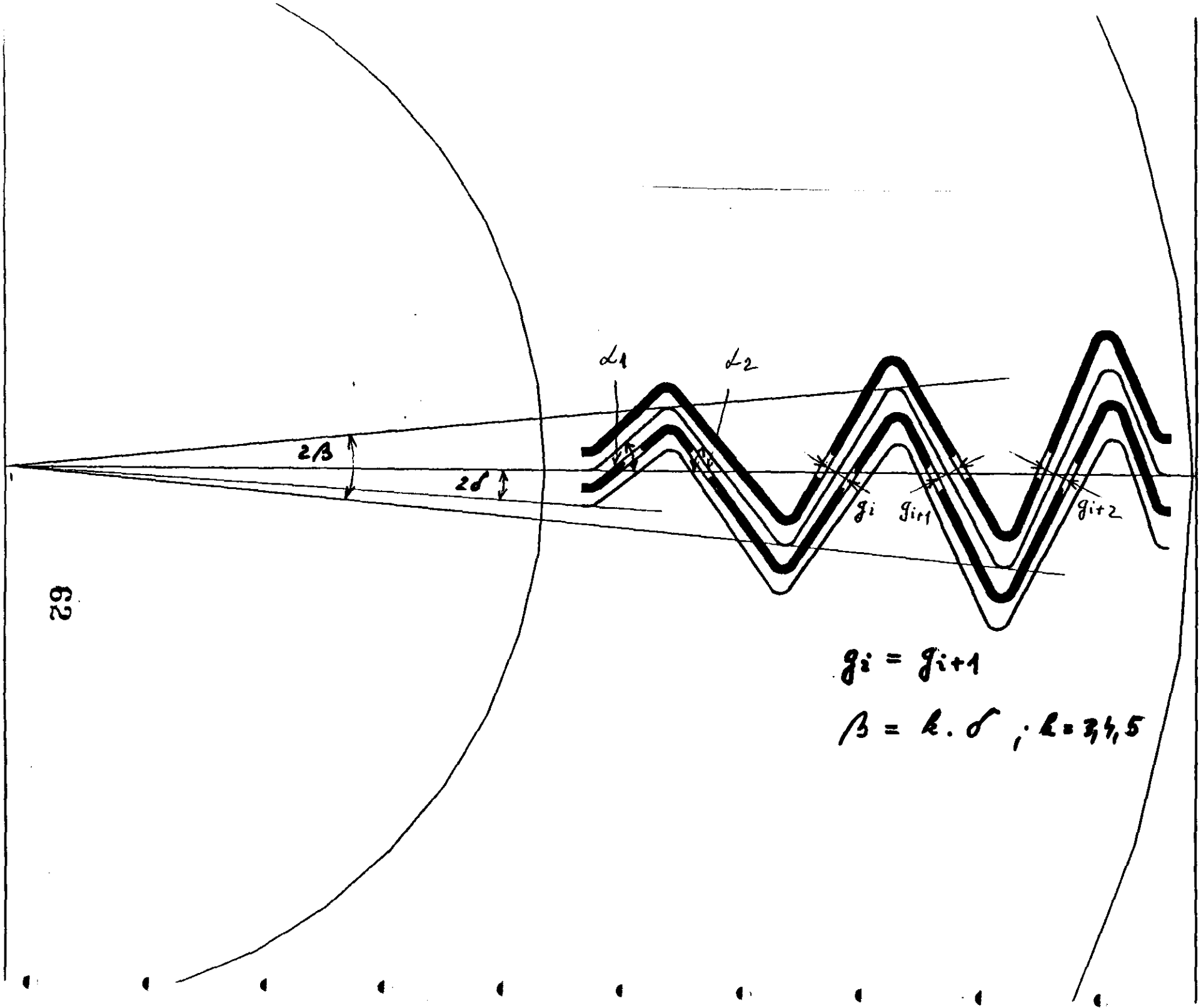
Jsers DIRECTIVES OPTIMIZED for this run :

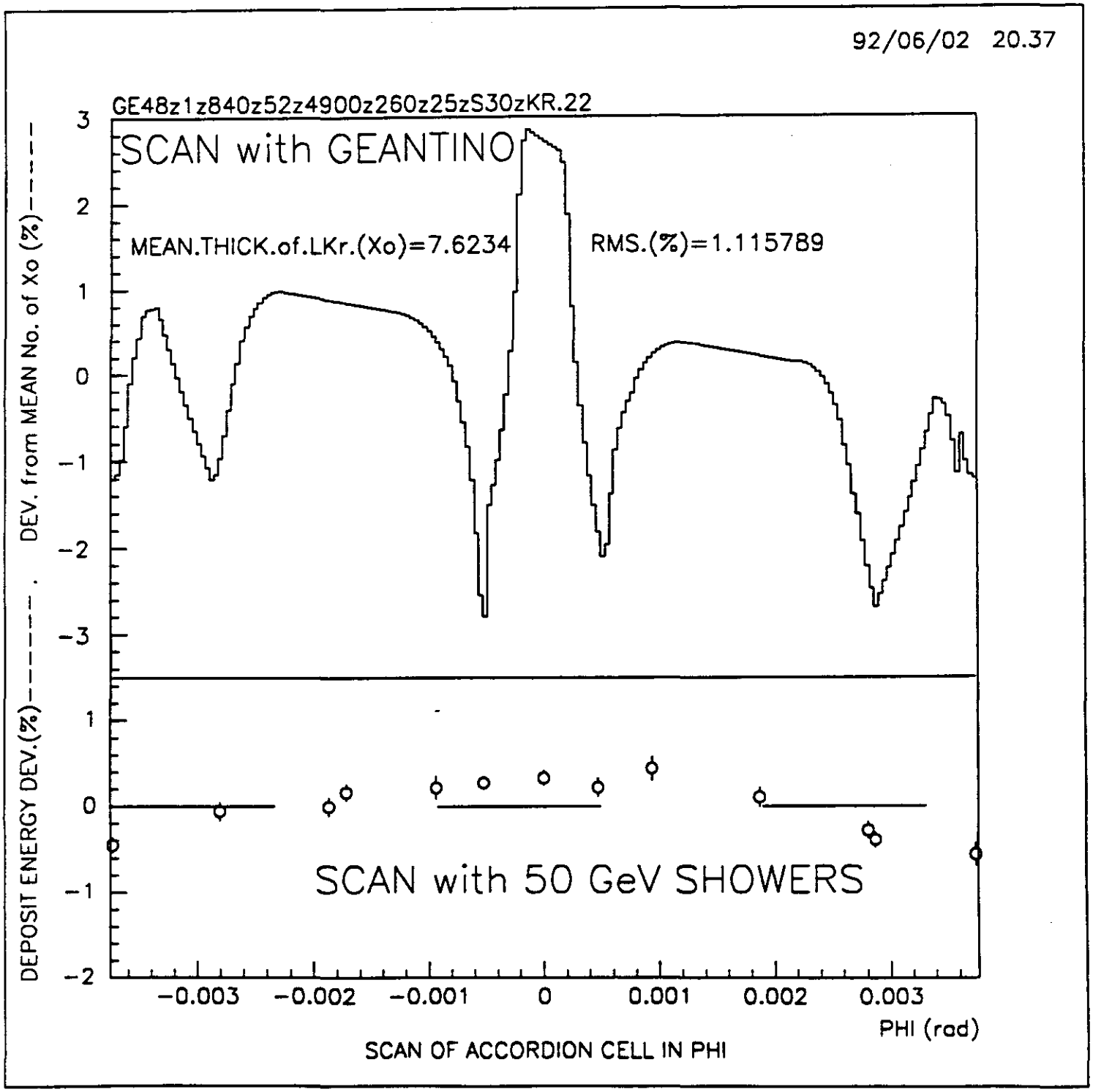
```
    75.00 cm  - Rin  of WARM CRYO wall (Al)
    76.00 cm  - Rout of WARM CRYO wall
    80.90 cm  - Rin  of COLD CRYO wall (Al)
    82.50 cm  - Rout of COLD CRYO wall
              - FRONT STRUCTURE :
                  2.00 cm  - LKr GAP
                  1.00 cm  - G10 for Electronics+Cables+Spacers
                  1.00 cm  - G10 FRAME with SS sheet holders
    86.43 cm  - INNER RADIUS of ACCORDION STRUCTURE
              - ACCORDION STRUCTURE :
                0.095785 cm  - LEAD thickness
                0.135785 cm  - ABSORBER thickness
                0.190254 cm  - LKr thickness
                0.556293 cm  - CELL thickness
                     840     - Total number of CELLS
                       4     - Number of CELLS in TOWER
                     210     - Number of TOWERS
                0.029920 rad - TOWER dimension in PHI
                0.003740 rad - DELTA
                   4.900     - Ratio BETA/DELTA
                0.018326 rad - BETA
                30.70820 deg - ALFA of first stack
                57.47947 deg - ALFA of last stack
                      14     - Number of STACKS
   138.53 cm  - OUTER RADIUS of ACCORDION STRUCTURE
              - BACKWARD STRUCTURE :
                  1.00 cm  - G10 FRAME with SS sheet holders
                  1.00 cm  - G10 for Electronics+Cables+Spacers
                  2.00 cm  - LKr GAP
   142.53 cm  - Rout of EM CAL
```

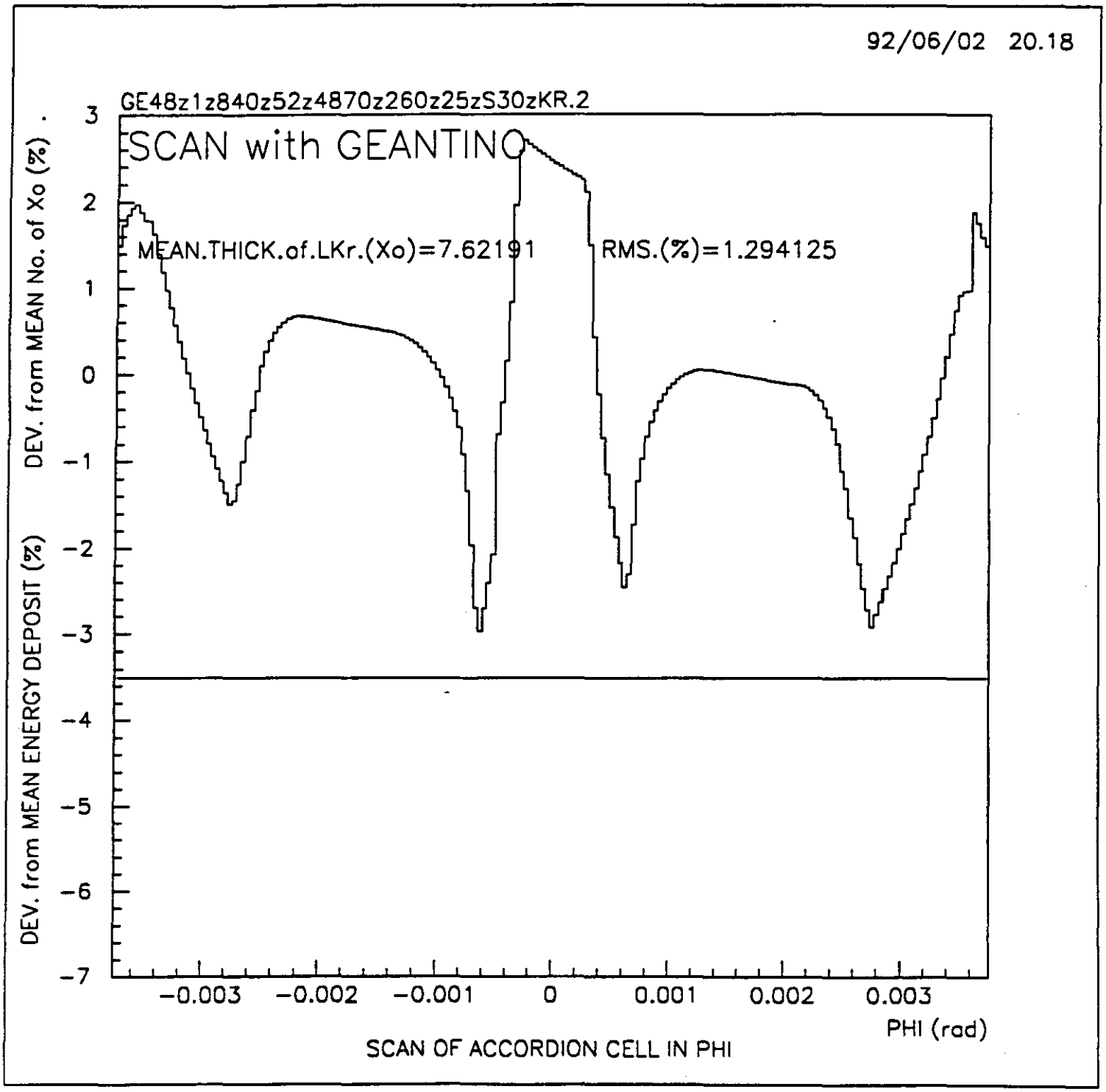
MEAN CORNER RADIUS - 2.5 mm

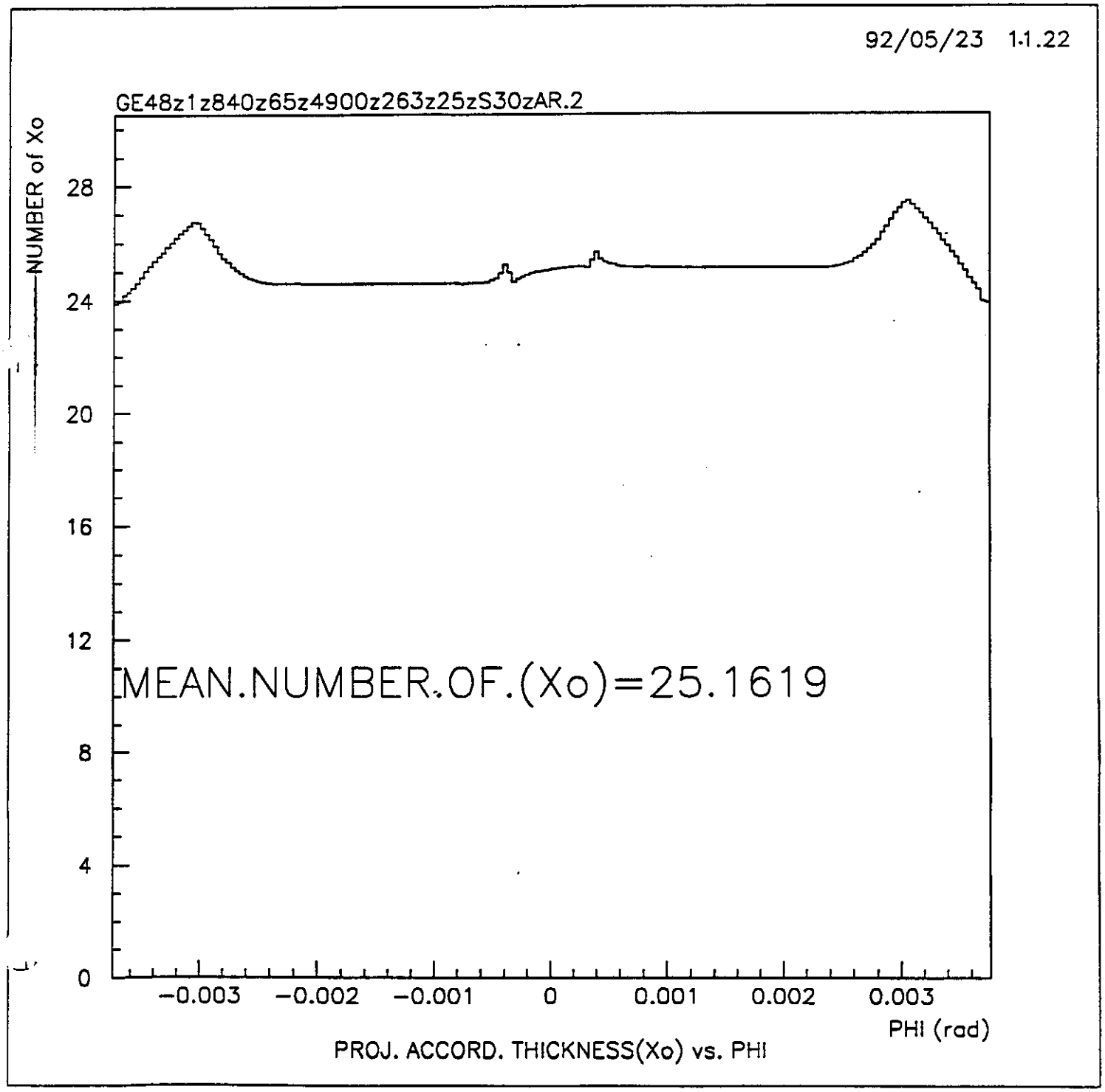
SS - 2 x 0.15 mm

GLUE - 2 x 0.05 mm


α_1
α_2
2β
2δ
g_i
g_{i+1}
g_{i+2}
$g_i = g_{i+1}$
$\beta = k \cdot \delta$; $k = 3, 4, 5$


92/06/02 20.37
GE48z1z840z52z4900z260z25zS30zKR.22
SCAN with GEANTINO
MEAN.THICK.of.LKr.(Xo)=7.6234
RMS.(%)=1.115789
DEV. from MEAN No. of Xo (%)
DEPOSIT ENERGY DEV.(%)
SCAN with 50 GeV SHOWERS
3
2
1
0
-1
-2
-3
1
0
-1
-2
-0.003
-0.002
-0.001
0
0.001
0.002
0.003
PHI (rad)
SCAN OF ACCORDION CELL IN PHI


92/06/02 20.18
GE48z1z840z52z4870z260z25zS30zKR.2
SCAN with GEANTINO
MEAN.THICK.of.LKr.(Xo)=7.62191
RMS.(%)=1.294125
DEV. from MEAN No. of Xo (%)
DEV. from MEAN ENERGY DEPOSIT (%)
3
2
1
0
-1
-2
-3
-4
-5
-6
-7
-0.003
-0.002
-0.001
0
0.001
0.002
0.003
PHI (rad)
SCAN OF ACCORDION CELL IN PHI


92/05/23 1.1.22
GE48z1z840z65z4900z263z25zS30zAR.2
NUMBER of Xo
28
24
20
16
12
8
4
0
MEAN.NUMBER.OF.(Xo)=25.1619
−0.003
−0.002
−0.001
0
0.001
0.002
0.003
PHI (rad)
PROJ. ACCORD. THICKNESS(Xo) vs. PHI

RD3

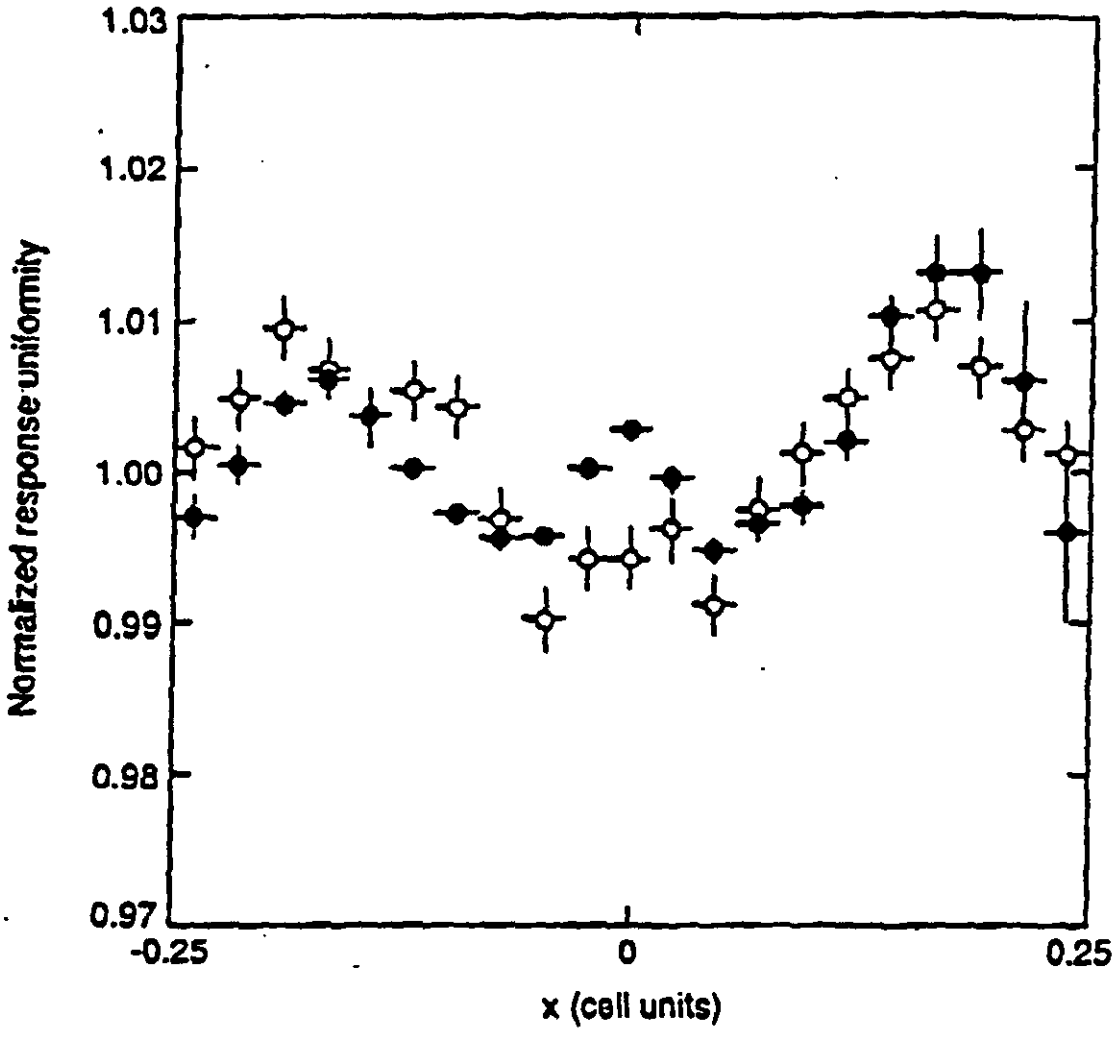
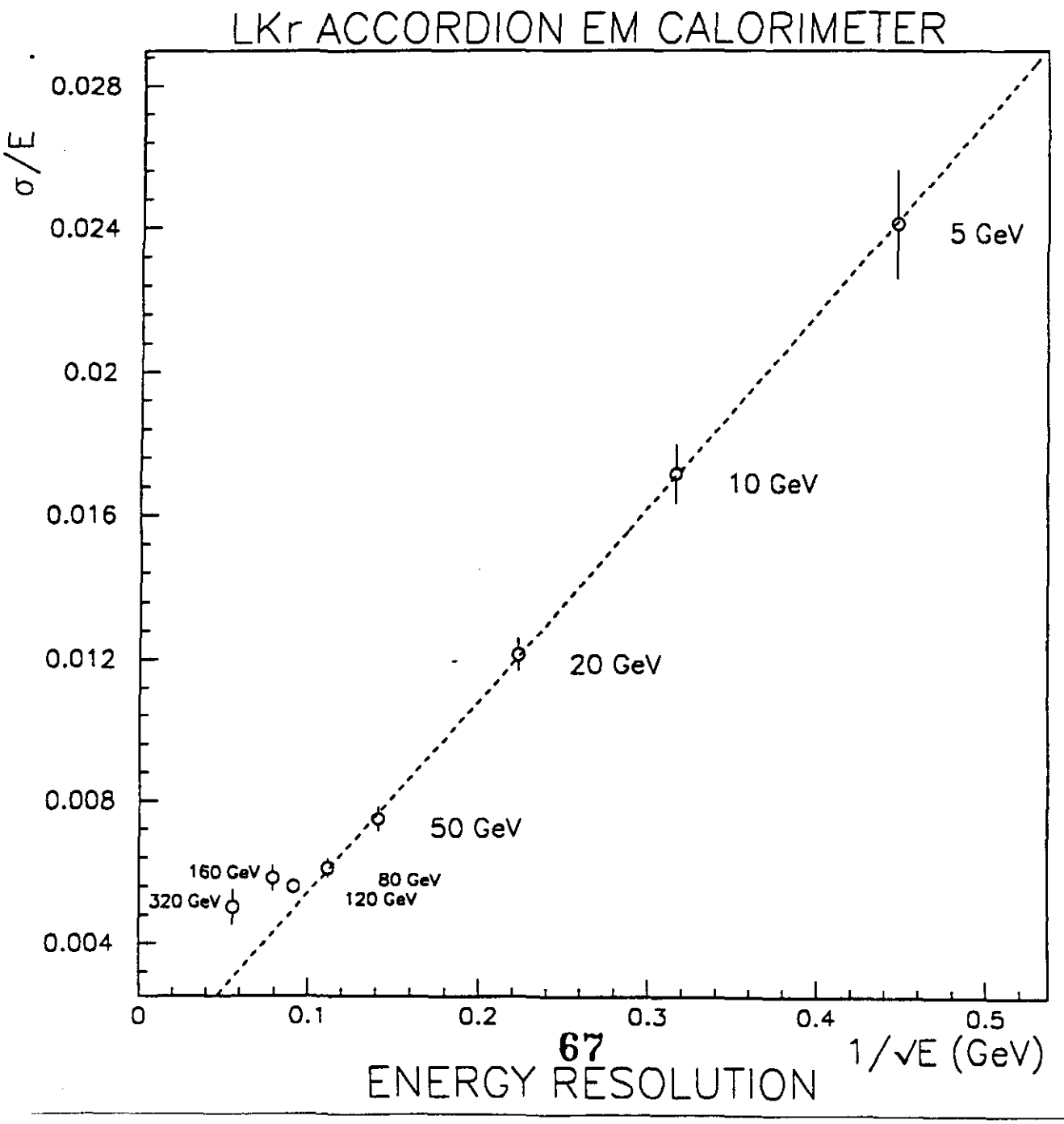


Figure 6: The calorimeter response, normalized to the mean value, as a function of the electron x position over half a cell for a 90 GeV beam. Closed circles: experimental points. Open circles: prediction of a full shower Monte Carlo simulation of the Accordion geometry.

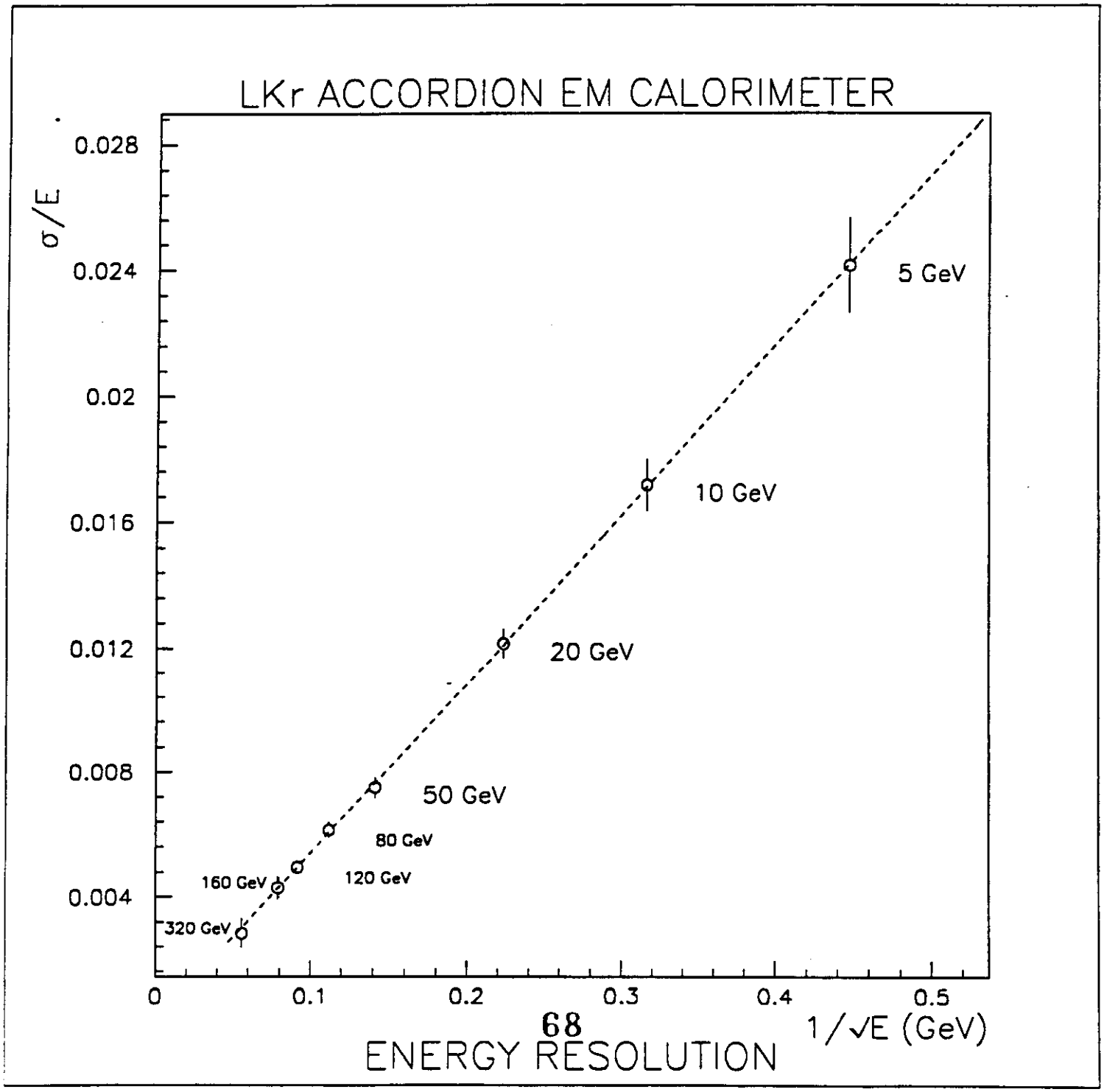
$$\sigma/E = \frac{a}{\sqrt{E}} + b \quad (5\text{-}80\ \text{GeV}) \qquad a = 5.41 \pm 0.28, \quad b = 0.0 \pm 0.05$$

$$\sigma/E = \frac{a}{\sqrt{E}} \oplus b \quad (5\text{-}320\ \text{GeV}) \qquad a = 5.2 \pm 0.04, \quad b = 0.29 \pm 0.01$$



ENERGY RESOLUTION

RESOLUTION AT ENERGIES ≥ 120 GeV
IS CORRECTED FOR LEAKAGE. ! ?



ENERGY [GeV]	<ENERGY> OUTSIDE ACCORDION STRUCTURE [GeV]	TAIL	<ENERGY> BACKWARD LEAKED [GeV]	TAIL	<ENERGY> SIDE LEAKED FROM 7x7 TOWERS ([GeV]	TAIL
20	0.33	→ 1.5	0.085	→ 1.2	0.19	→ 0.3
50	0.83	→ 3	0.27	→ 3	0.46	→ 0.7
80	1.41	→ 4	0.54	→ 3	0.71	→ 1.0
120	2.21	→ 8	1.05	→ 6	0.91	→ 1.4
160 *	3.72	→ 19	1.66	→ 13	1.54	→ 2.1
320 *	9.6	→ 25	4.96	→ 17	3.45	→ 4.0

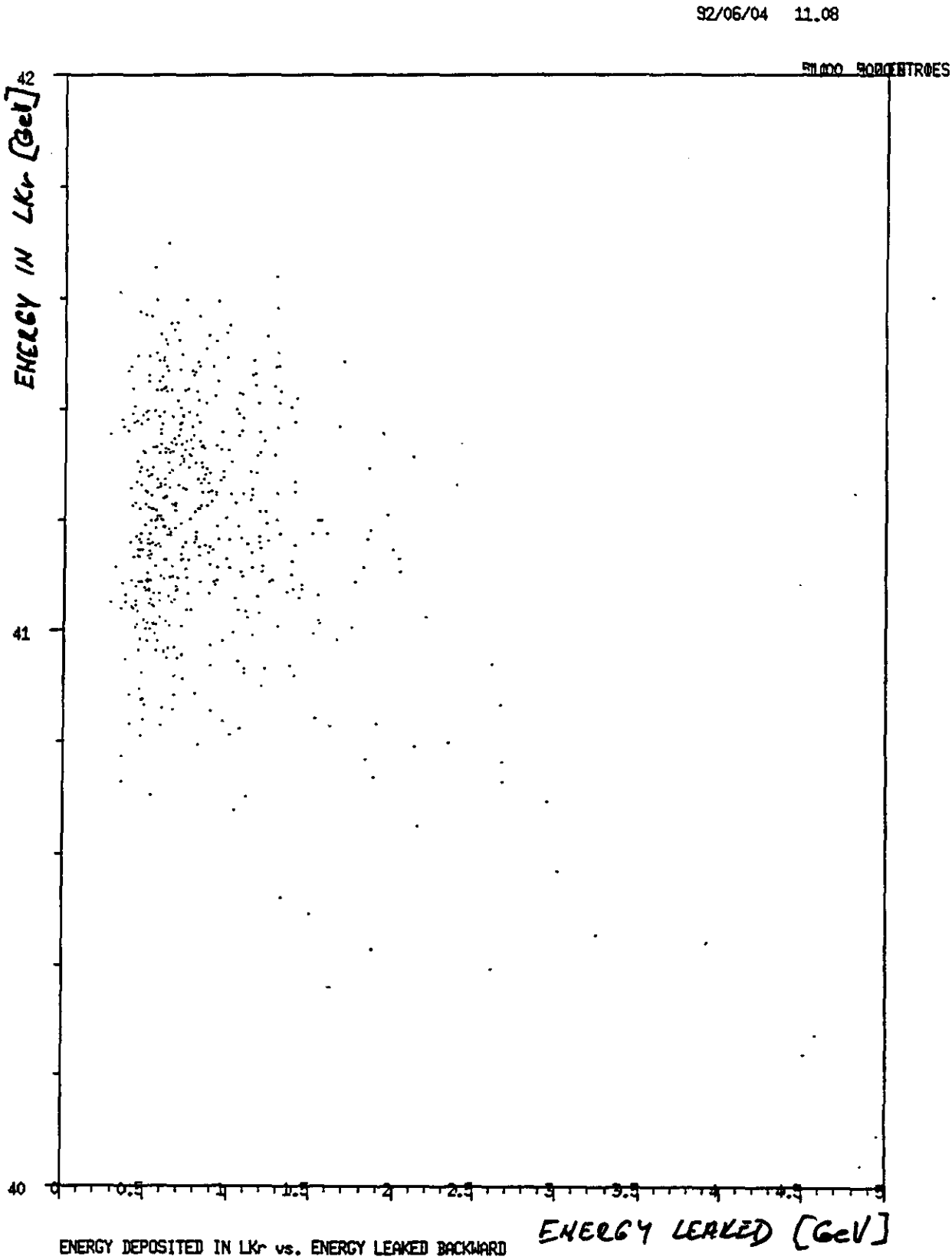
* PRELIMINARY
LOWER STATISTICS

ENERGY [GeV]	$\sigma/\sqrt{E}$ [%] NO CORR.	BACK LEAK CORRECTED	CORR. FOR ALL LEAKED ENERGY	CONTRIBUTION OF BACK LEAK	OTHERS
1	5.8 ± 0.2				
5	5.4 ± 0.2				
10	5.43 ± 0.2				
20	5.43 ± 0.2				
50	5.3 ± 0.2	5.6	5.25		
80	5.48 ± 0.2	5.8	5.43		
120	6.11 ± 0.2	5.8	5.41	1.9	2.1
160	7.45 ± 0.6*	5.96	5.43	4.5	2.5
320	8.9 ± 1.0*	6.8	5.5	5.7	4.0

* PRELIMINARY
LOWER STATISTICS

of X_0 ↑ with η

120 GeV



ENERGY DEPOSITED IN LKr vs. ENERGY LEAKED BACKWARD

ers DIRECTIVES OPTIMIZED for this run :

```
 75.00 cm  - Rin  of WARM CRYO wall (Al)
 76.00 cm  - Rout of WARM CRYO wall
 8[illegible].90 cm  - Rin  of COLD CRYO wall (Al)
 82.50 cm  - Rout of COLD CRYO wall
           - FRONT STRUCTURE :
               2.00 cm  - LAr GAP
               1.00 cm  - G10 for Electronics+Cables+Spacers
               1.00 cm  - G10 FRAME with SS sheet holders
 86.43 cm  - INNER RADIUS of ACCORDION STRUCTURE
           - ACCORDION STRUCTURE :
             0.094465 cm  - LEAD thickness
             0.134465 cm  - ABSORBER thickness
             0.188405 cm  - LAr thickness
             0.551275 cm  - CELL thickness
                  840     - Total number of CELLS
                    4     - Number of CELLS in TOWER
                  210     - Number of TOWERS
             0.029920 rad - TOWER dimension in PHI
             0.003740 rad - DELTA
                4.900     - Ratio BETA/DELTA
             0.018326 rad - BETA
             31.56763 deg - ALFA of first stack
             60.85427 deg - ALFA of last stack
                   18     - Number of STACKS
151.52 cm  - OUTER RADIUS of ACCORDION STRUCTURE
           - BACKWARD STRUCTURE :
               1.00 cm  - G10 FRAME with SS sheet holders
               1.00 cm  - G10 for Electronics+Cables+Spacers
               2.00 cm  - LAr GAP
155.52 cm  - Rout of EM CAL
```

```
Users DIRECTIVES OPTIMIZED for this run :

    75.00 cm  - Rin  of WARM CRYO wall (Al)
    76.00 cm  - Rout of WARM CRYO wall
    80.90 cm  - Rin  of COLD CRYO wall (Al)
    82.50 cm  - Rout of COLD CRYO wall
              - FRONT STRUCTURE :
                  2.00 cm  - LAr GAP
                  1.00 cm  - G10 for Electronics+Cables+Spacers
                  1.00 cm  - G10 FRAME with SS sheet holders
    86.43 cm  - INNER RADIUS of ACCORDION STRUCTURE
              - ACCORDION STRUCTURE :
                0.125530 cm  - LEAD thickness
                0.165530 cm  - ABSORBER thickness
                0.175876 cm  - LAr thickness
                0.557282 cm  - CELL thickness
                     840     - Total number of CELLS
                       4     - Number of CELLS in TOWER
                     210     - Number of TOWERS
                0.029920 rad - TOWER dimension in PHI
                0.003740 rad - DELTA
                   4.880     - Ratio BETA/DELTA
                0.018251 rad - BETA
                30.53631 deg - ALFA of first stack
                57.40606 deg - ALFA of last stack
                      14     - Number of STACKS
   138.49 cm  - OUTER RADIUS of ACCORDION STRUCTURE
              - BACKWARD STRUCTURE :
                  1.00 cm  - G10 FRAME with SS sheet holders
                  1.00 cm  - G10 for Electronics+Cables+Spacers
                  2.00 cm  - LAr GAP
   142.49 cm  - Rout of EM CAL
```

ENERGY RESOLUTION

LIQUID KRYPTON AS ACTIVE MEDIUM

* 100 keV CUTS on GAMA, ELECTRONS and DELTA RAYS PRODUCTION
* 10 keV CUTS 'IMPROVE' PRESENTED RESOLUTION BY 0.4 %

AT THETA = 90°

* FIT IN ENERGY RANGE (5 - 80) GeV

$$\sigma/E = \frac{a}{\sqrt{E}} + b \qquad a = 5.41 \pm 0.28 \quad b = 0.0 \pm 0.05$$

- PARALLEL PLATE GEOMETRY WITH THE SAME STRUCTURE AT 20 GeV (51.7 cm DEPTH; ~ 25 Xo)

  SIGMA/SQRT(E) = (4.7 +/- 0.2) % AT 20 GeV 90°
  → (4.9 +/- 0.2)% at 20 GeV 45°

- LIQUID ARGON AS ACTIVE MEDIUM

  1. STRUCTURE - THE SAME AS FOR LKR BUT 65.1 cm in DEPTH TO GET 25 Xo.

     SIGMA/SQRT(E) = (6.25 +/- 0.2) % AT 50 GeV

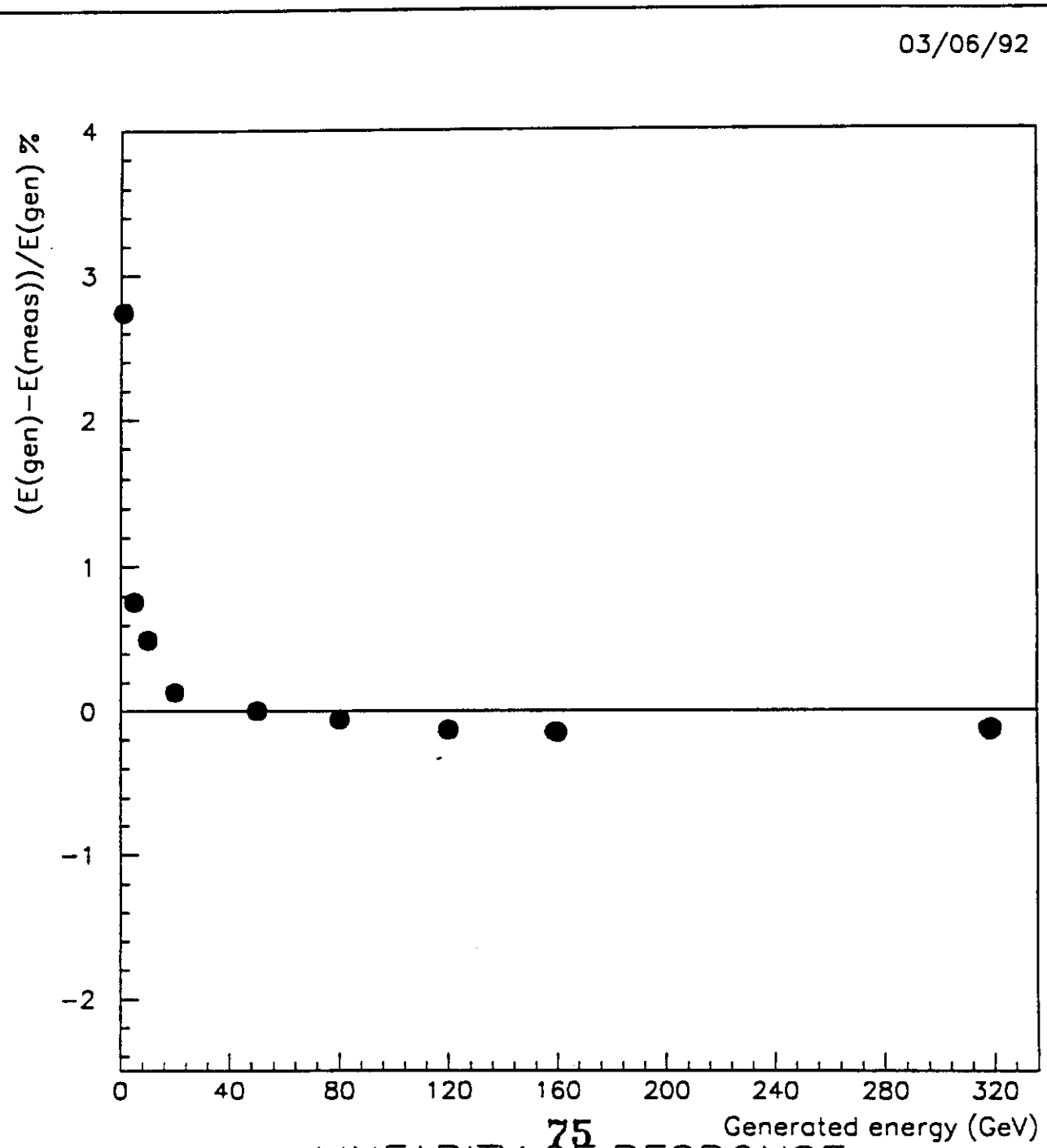
  2. STRUCTURE - MORE DENSE TO GET 25 Xo IN 52.1 cm

     SIGMA/SQRT(E) = (7.03 +/- 0.2) % AT 50 GeV
     (6.91 +/- 0.2) % AT 10 GeV

* FIT IN ENERGY RANGE (5 -320) GEV
  ADDING SAMPLING AND CONSTANT TERM IN QUADRATURE

$$\sigma/E = \frac{a}{\sqrt{E}} \oplus b \qquad a = 5.2 \pm 0.04 \quad b = 0.29 \pm 0.01$$

LKr EM CAL



LINEARITY OF RESPONSE

THETA DEPENDENCE OF ENERGY RESOLUTION

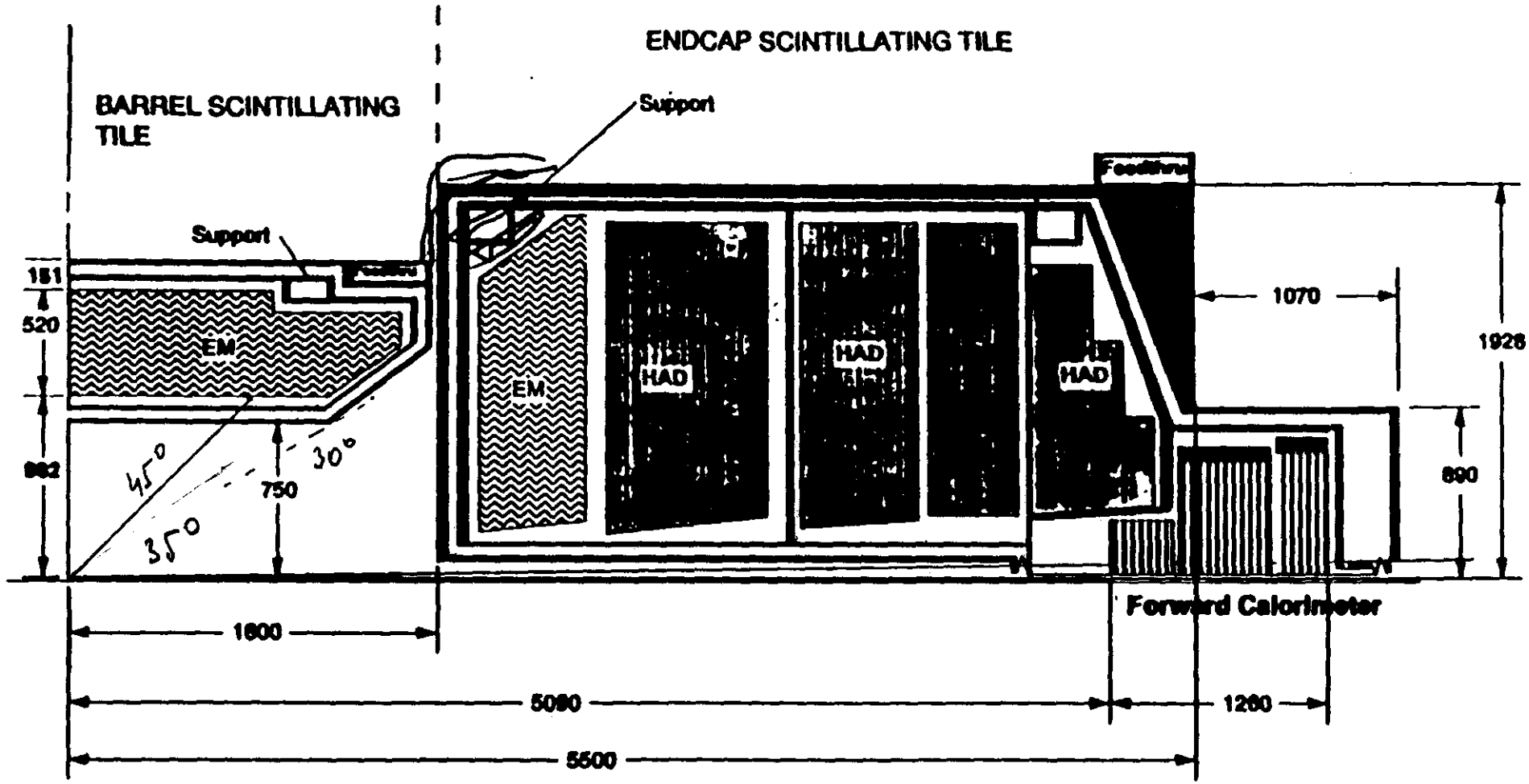
LKr

THETA [DEG]	ENERGY [GeV]	$\sigma/\sqrt{E}$ [%] ± 0.2 %
90	50	5.3
45	50	6.4
30	50	8.8 ± 0.25 %
90	10	5.4
60	10	5.45
30	10	8.2

LAr : 2. STRUCTURE [25 X_0 in 52.1 cm]

THETA [DEG]	ENERGY [GeV]	RESOLUTION $\sigma/\sqrt{E}$ [%] ± 0.2 %
90	50	7.03
90	10	6.91
45	10	7.82

BARREL/ENDCAP EM - LIQUID ARGON PLUG-TILE ENDCAP

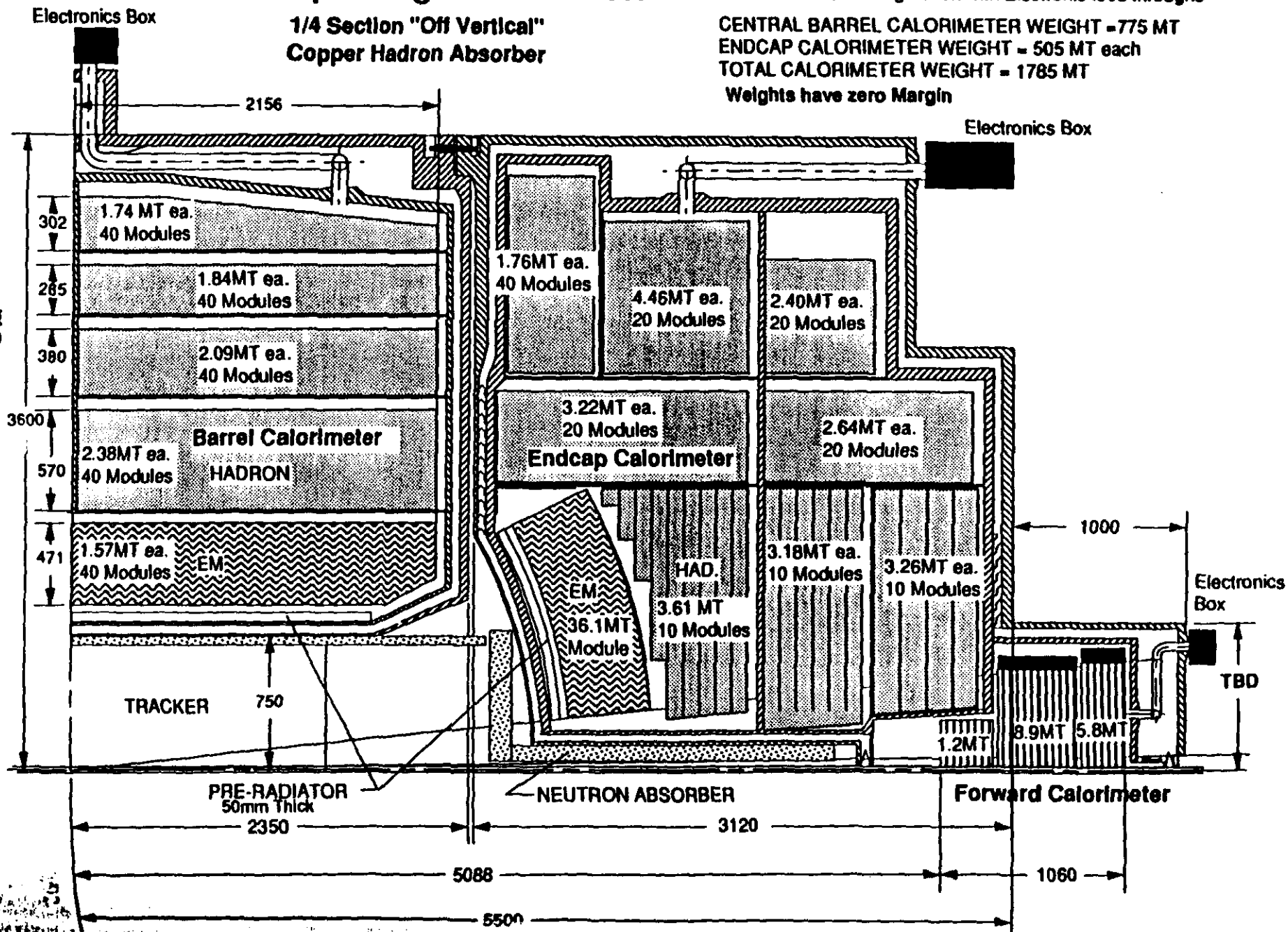


GEM Liquid Argon Calorimeter

1/4 Section "Off Vertical"
Copper Hadron Absorber

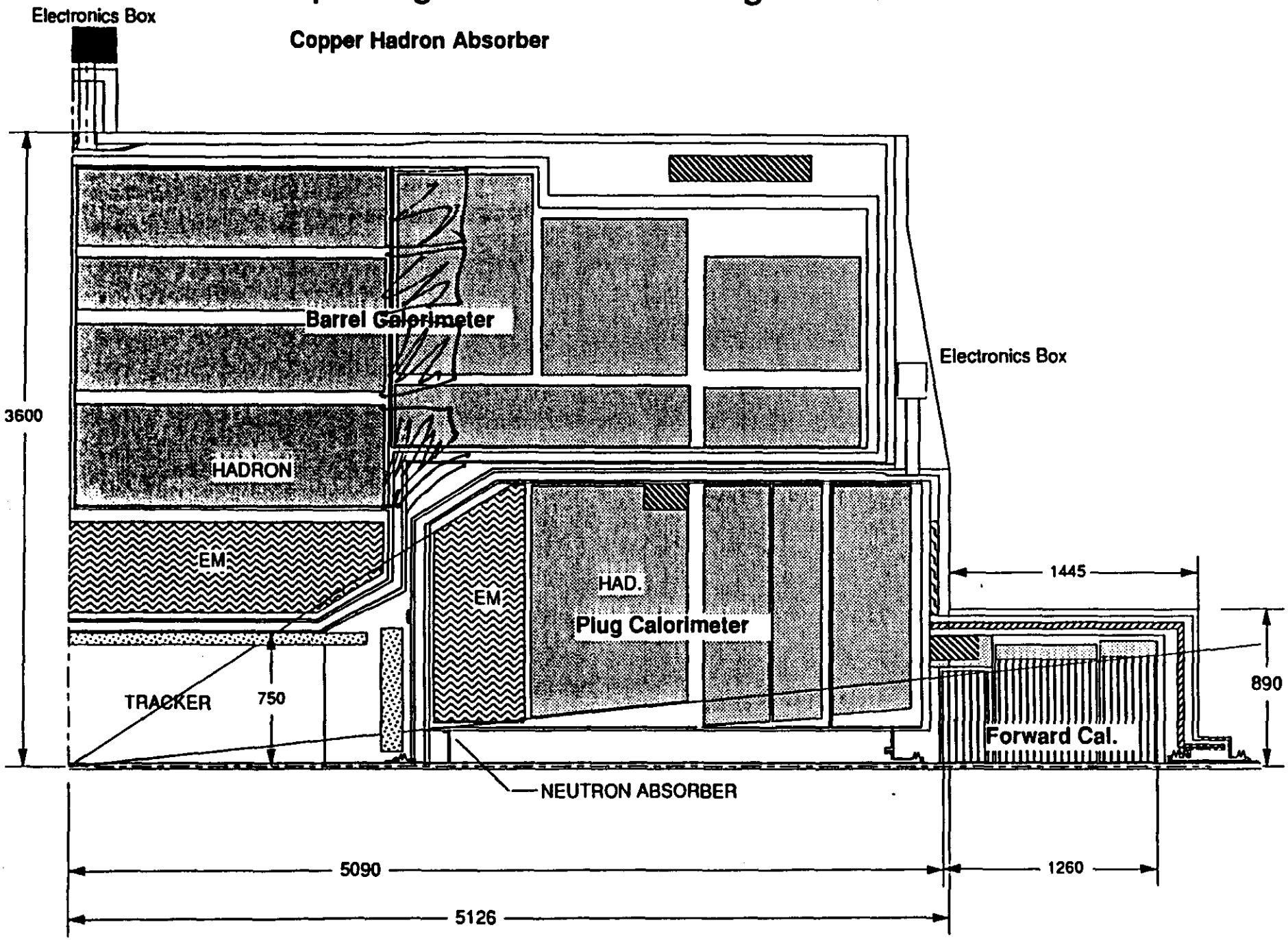
Shows General Configuration with Electronic feed throughs

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



LLMason 3/23/92

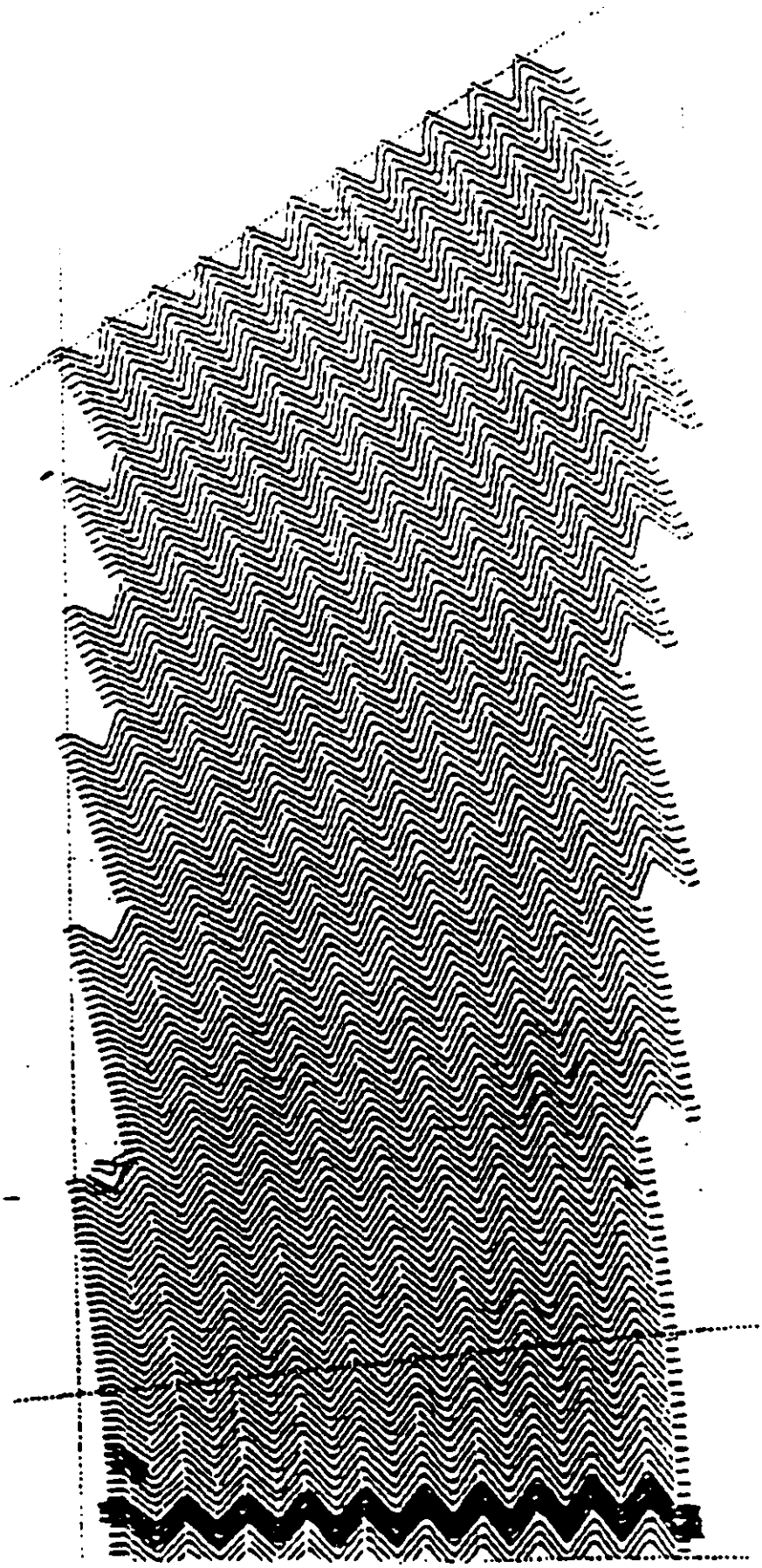
GEM Liquid Argon Calorimeter - Plug Version



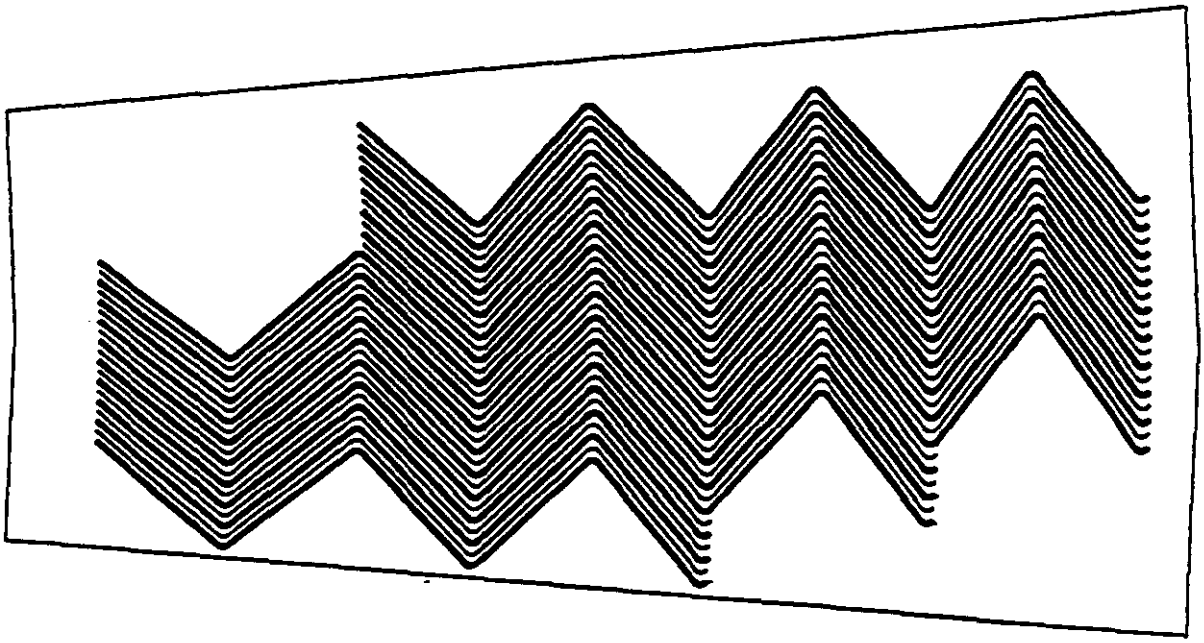
LLMason GEMLAC.Plug Version 5/13/92

POSSIBLE APPROACH TO ENDCAP

PROJECTIVE ACCORDION GEOMETRY

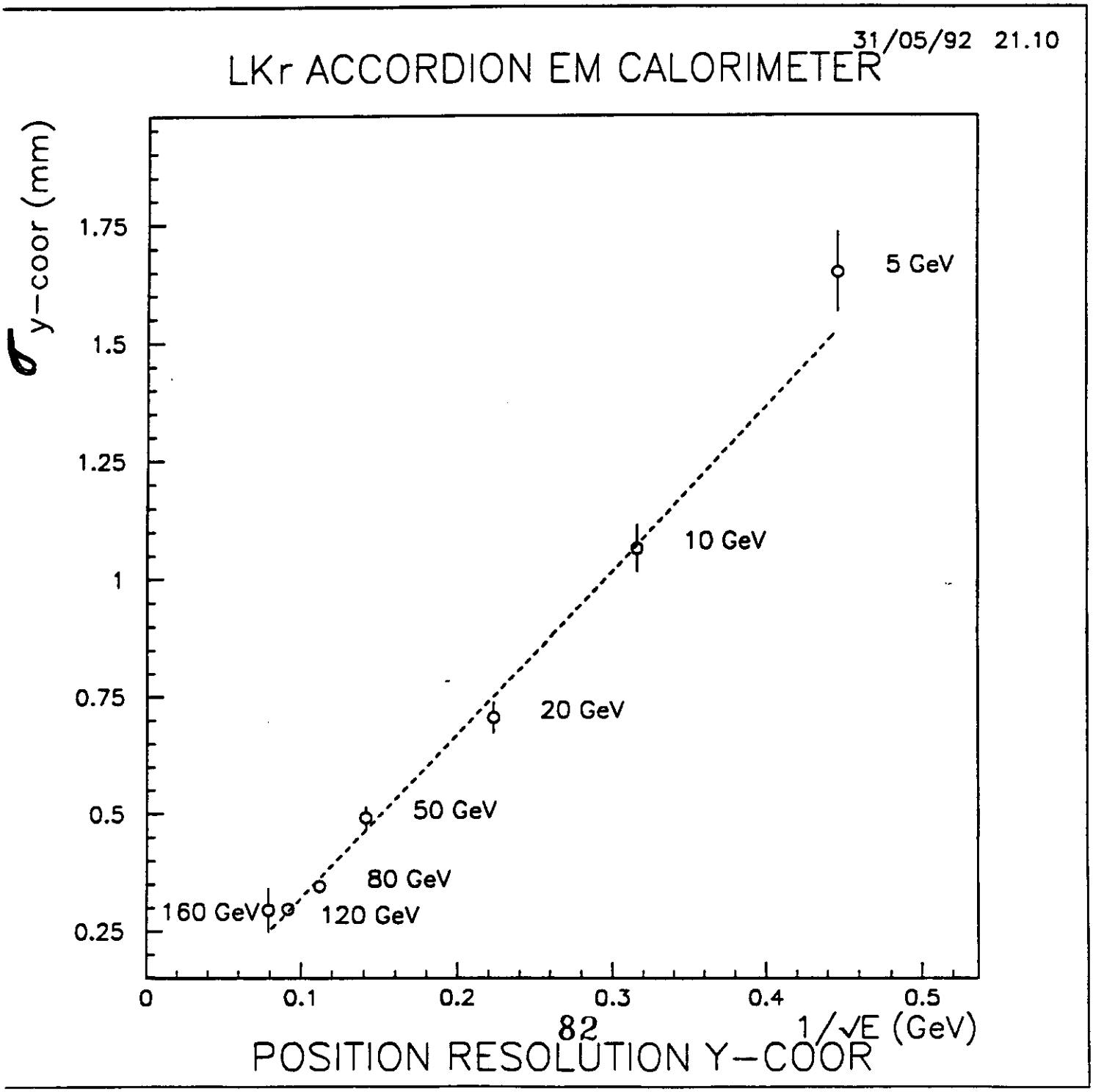


M. LELTCHOUK, COLUMBIA

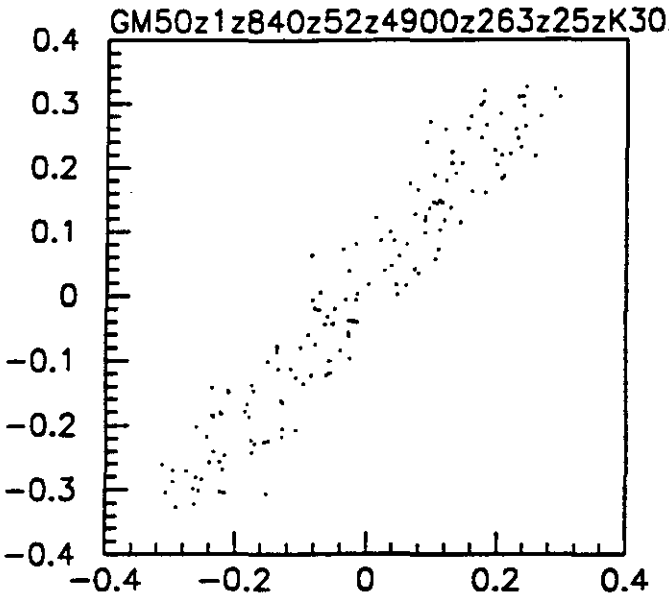


FROM FIT

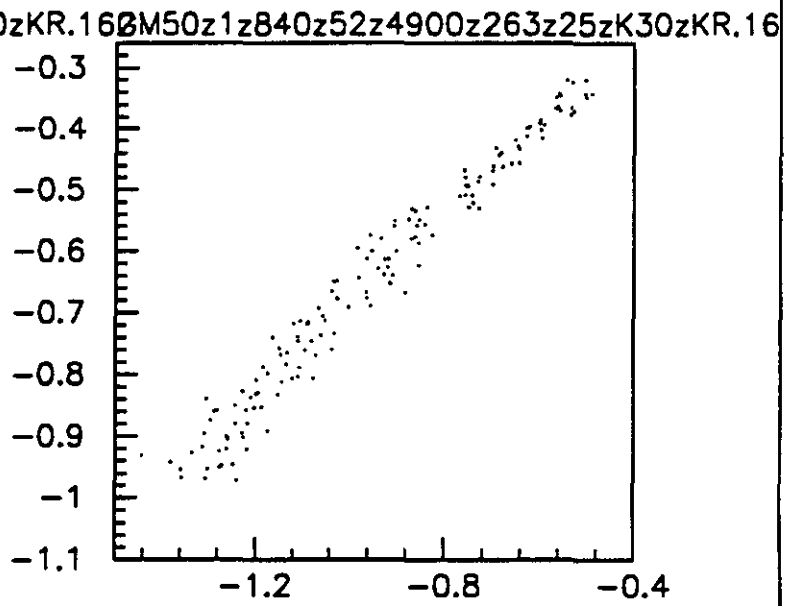
$$\sigma_y = \frac{(3.47 \pm 0.14)\ mm}{\sqrt{E}} \oplus (0.026 \pm 0.018)\ mm$$



92/05/31 21.43



YPOS generated vs. recovered



ZPOS generated vs. recovered

POSITION AND ANGULAR RESOLUTION AT 90°

* CALORIMETER IS DIVIDED TO TWO FLOORS AT 8.9 X_0

ENERGY [GeV]	$\sigma_{Y_{POS}}$* [mm]	$\sigma_{Z_{POS}}$* [mm]	σ_{PHI} [mrad]	$\sigma_{Y_{ANG}}$* [mm]	σ_{THETA} [mrad]	$\sigma_{Z_{ANG}}$* [mm]
10	1.13	0.74	21.8	2.9	16.9	1.94
20	0.77	0.56	14.2	2.3	10.9	1.47
50	0.50	0.33	9.5	1.99	5.9	0.85
80	0.37	0.26	7.3	1.78	4.4	0.65
120	0.30	0.22	6.0	1.5	3.3	0.51
160	0.29	0.20	5.9	1.4	3.1	0.49

* ON THE FRONT FACE OF CALORIMETER

CHARGE COLLECTION AND PULSE SHAPING

* ELECTRIC FIELD INHOMOGENITIES IN THE CORNERS
* VARIATION OF GAP WIDTH IN THE STRAIGHT SECTIONS
* CHARGE RECOMBINATION
* DRIFT VELOCITY

* RD3
  - FOR NOT OPTIMIZED NONPROJECTIVE VERSION :
    - M.C. DID'NT SHOW ANY CHANGE IN RESOLUTION
    - EXPERIMENT

      APPLIED VOLTAGE IN THE RANGE FROM 6 - 12 kV/cm
      AT 122 GeV NO CHANGE IN THE ENERGY RESOLUTION
      WAS OBSERVED

* PROJECTIVE GEOMETRY
  - ANGLES AND DIMENSIONS OF CORNERS VARY
  - DETAILED STUDY ON THE WAY
  - FIELD MAPS, RECOMBINATION DONE BY IULIU STUMER

* FIRST RESULT ON FAST CHARGE COLLECTION AND PULSE SHAPING
  (NOT CONSIDERING FIELD INHOMOGENITIES AND RECOMBINATION)

  AT 20 GeV with 10 keV CUTS;

  ALL CHARGE CONTRIBUTES WITH SAME WEIGHT :

  SIGMA/SQRT(E) = (4.98 +/- 0.2) %

  CHARGE CONTRIBUTION WEIGHTED :

  SIGMA/SQRT(E) = (4.99 +/- 0.2) %

  - NO EFECT ON ENERGY RESOLUTION

FIELD STRENGTH AT 2 kV/gap

10.53 kV/cm - constant field region
11.72 kV/cm - convex bend (read. el.)
2.94 kV/cm - concave bend (read. el.)

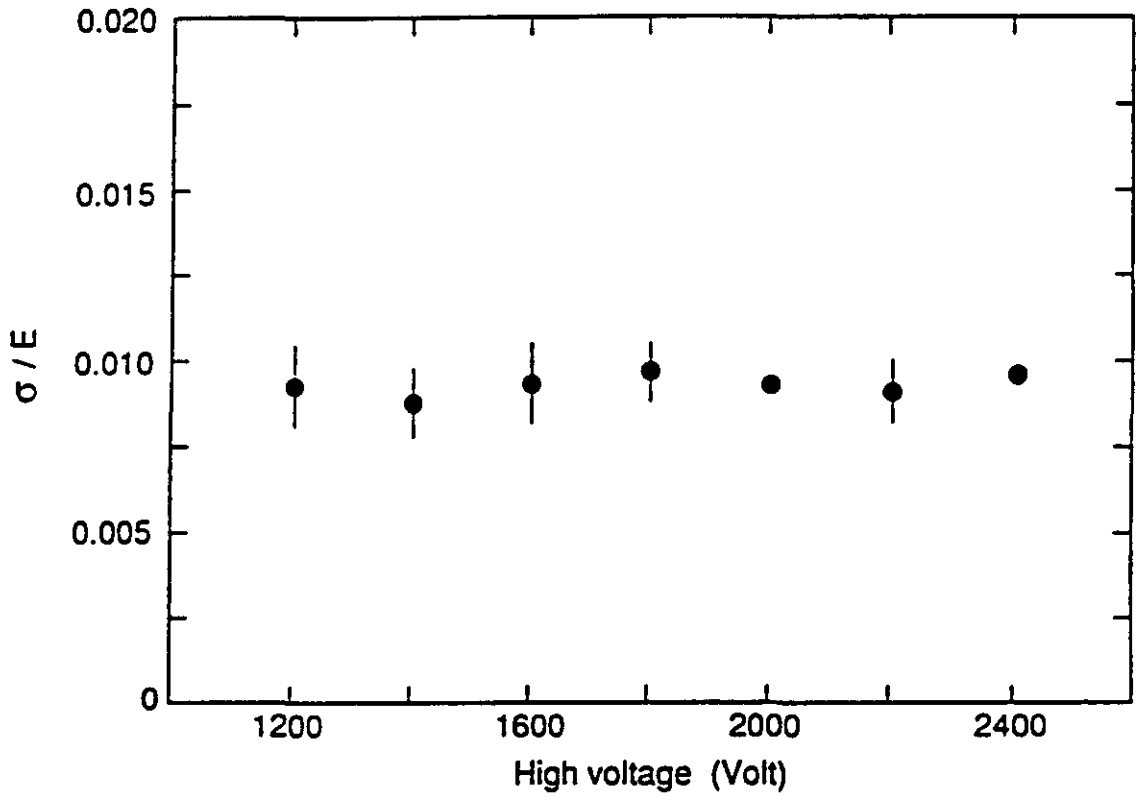
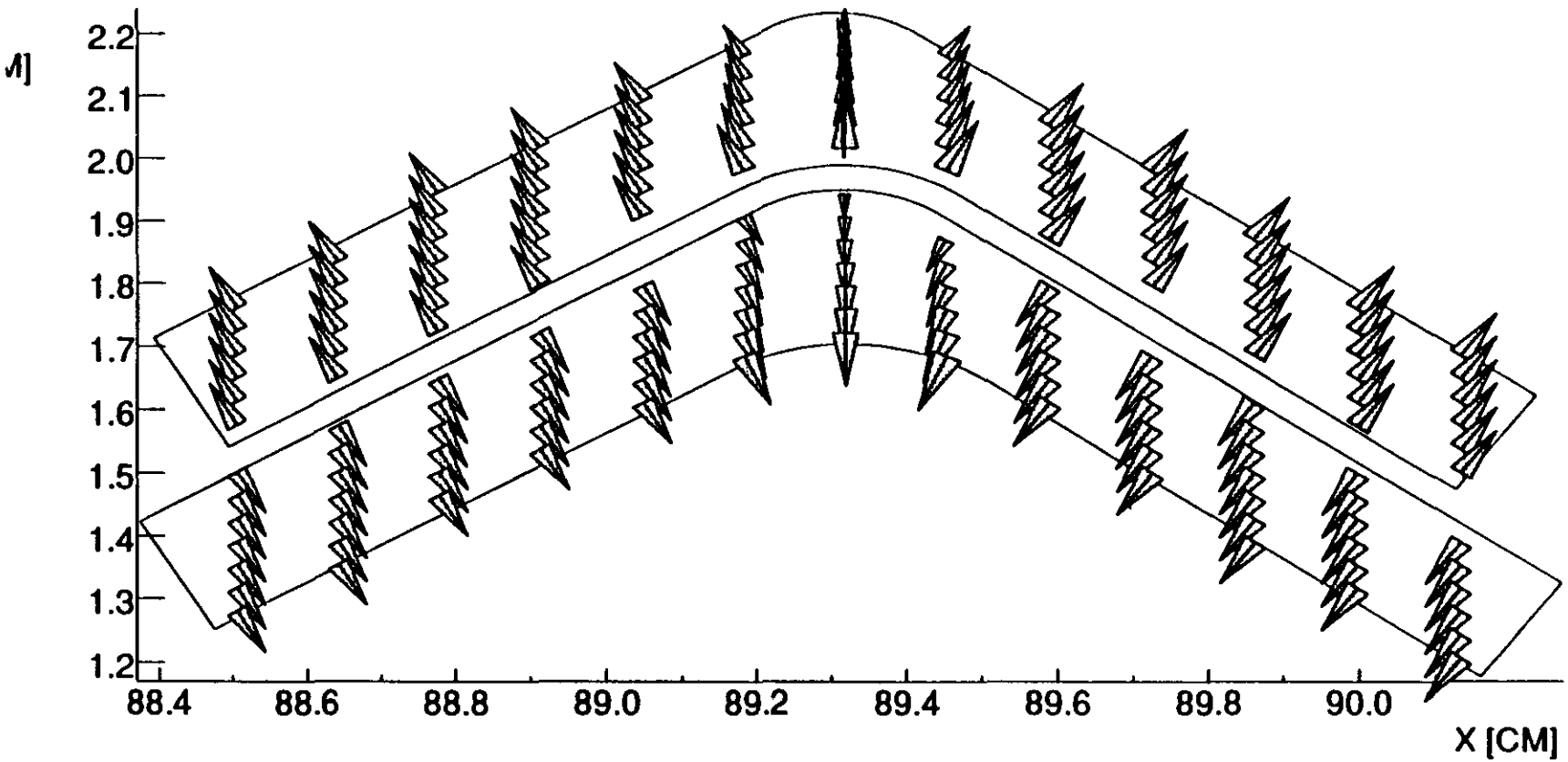


Figure 7: Energy resolution at 122 GeV as a function of the high voltage applied to the test module

IULIU STUMER, BNL

02.STRES
ay/92 12:17:06 Page 5 : RECO MESH=NO MATE=BOUND +ERASE

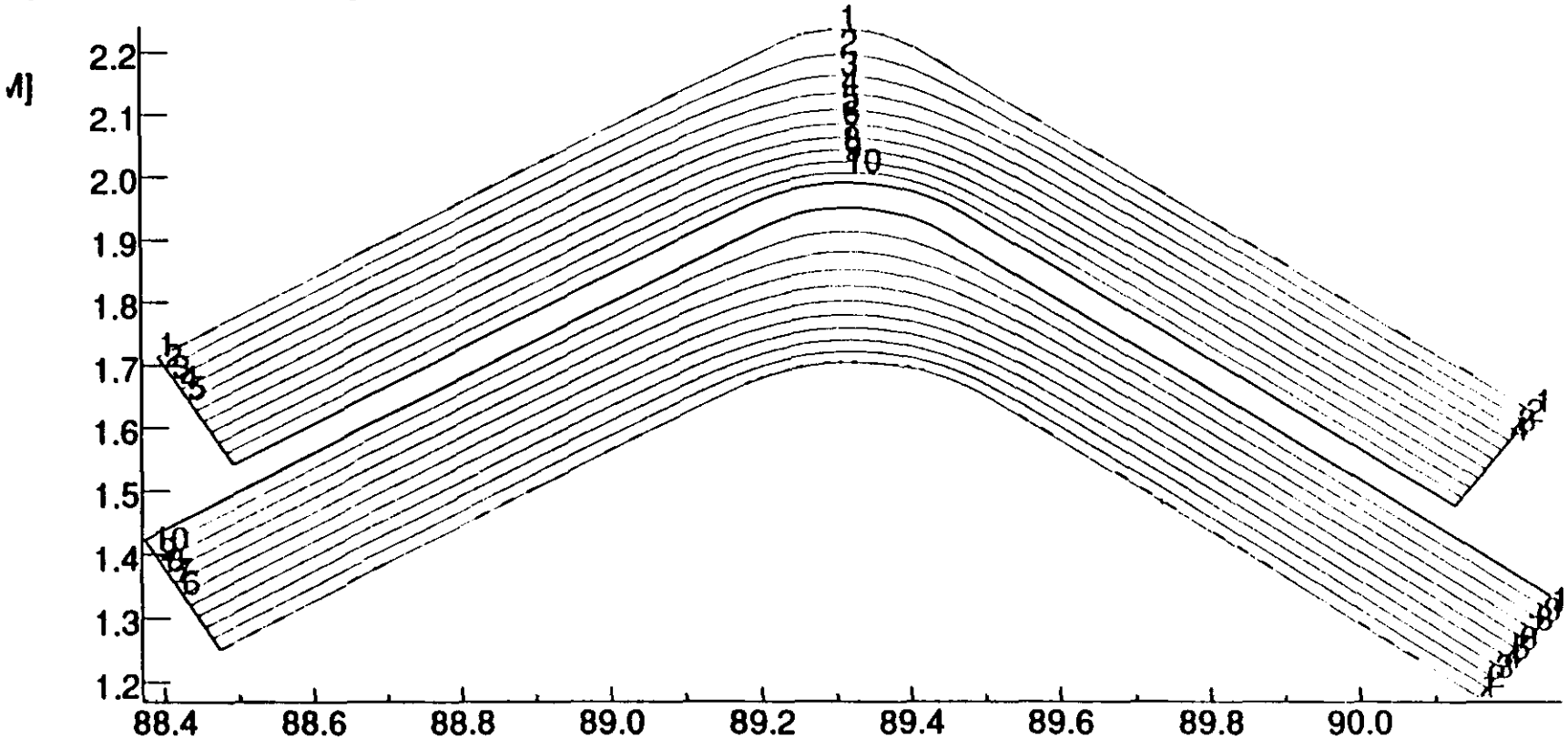


EM=QUAD SYMM=XY SOLN=V SCALE=1.0 FIEL=ELEC
atic Solution Mesh 2400 Elements 6 Regions

VF/PI

IULIU STUHER, BNL

02.STRES
ay/92 12:21:11 Page 11 : CONT COMP=POT LINES=10 +ERASE



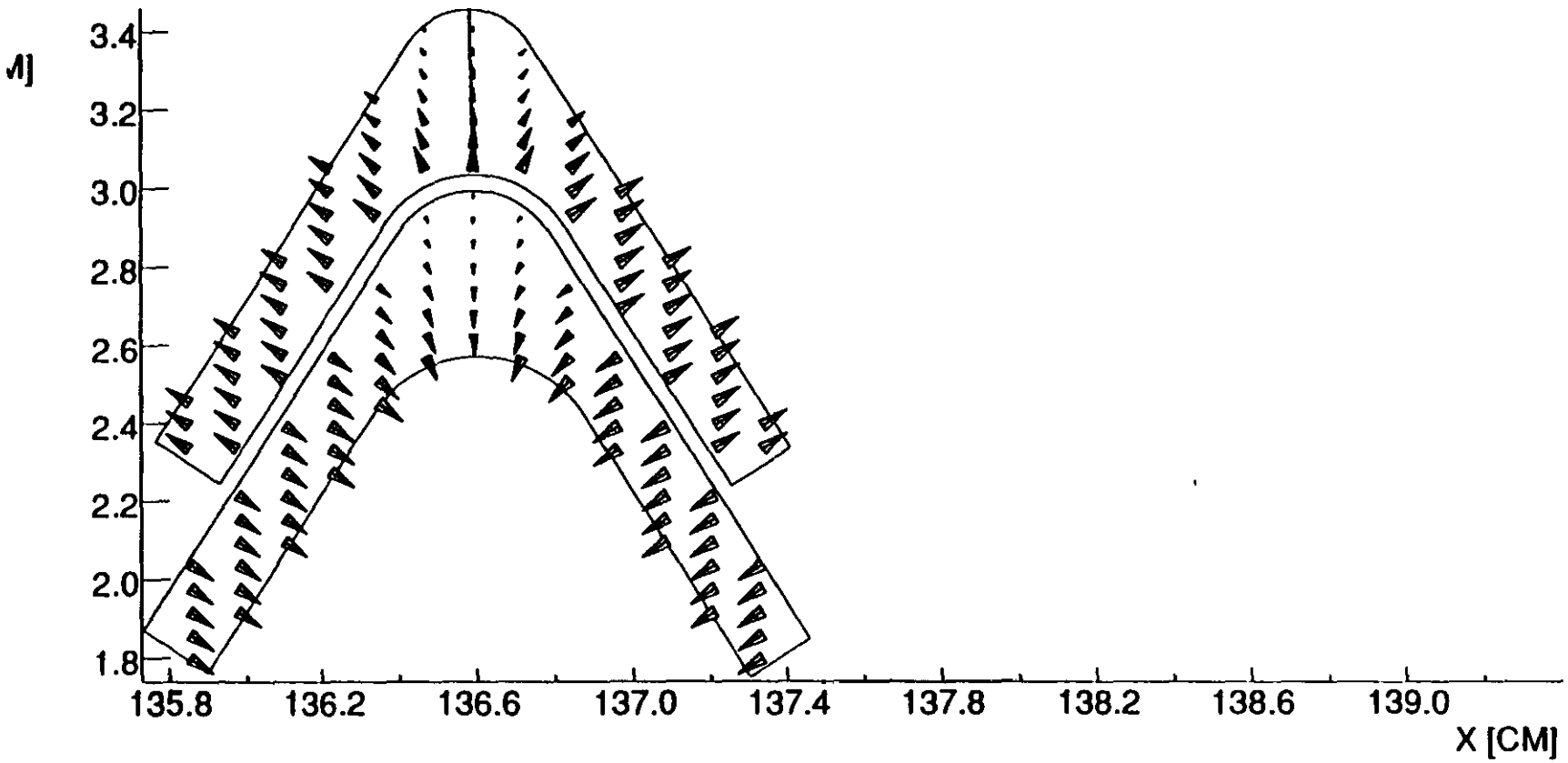
omponent: POT
linimum: 0.0, Maximum: 2000.0, Interval: 200.0

EM=QUAD SYMM=XY SOLN=V SCALE=1.0 FIEL=ELEC
atic Solution Mesh 2400 Elements 6 Regions

VF/PI

IULIU STUMER, BNL

14.STRES
ay/92 12:54:18 Page 7 : RECO MESH=NO MATE=BOUND +ERASE

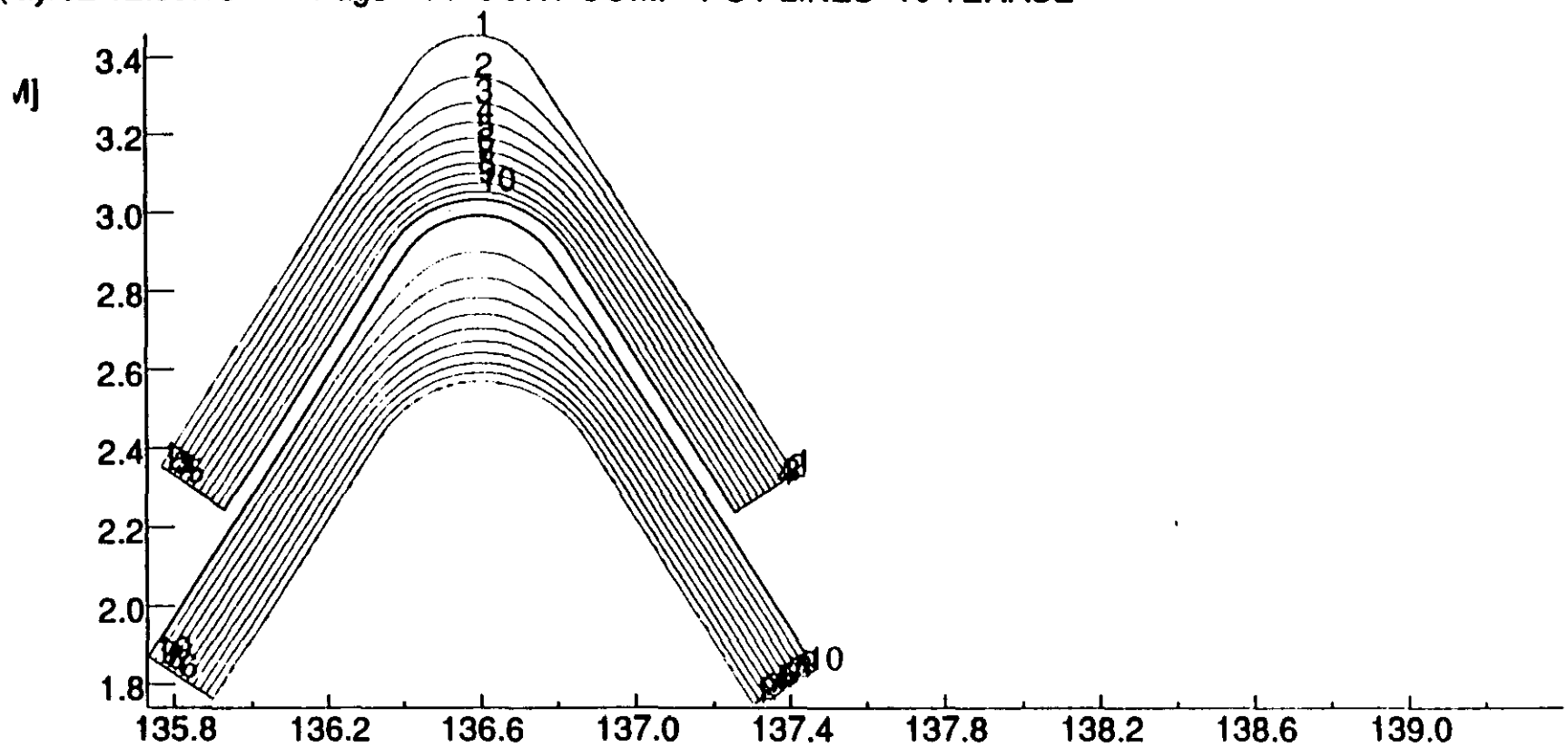


EM=QUAD SYMM=XY SOLN=V SCALE=1.0 FIEL=ELEC
atic Solution Mesh 2400 Elements 6 Regions

VF/PI

IULIU STUMER, BNL

14.STRES
ay/92 12:30:23 Page 4 : CONT COMP=POT LINES=10 +ERASE



omponent: POT
linimum: 0.0, Maximum: 2000.0, Interval: 200.0

EM=QUAD SYMM=XY SOLN=V SCALE=1.0 FIEL=ELEC
atic Solution Mesh 2400 Elements 6 Regions

VF/PI

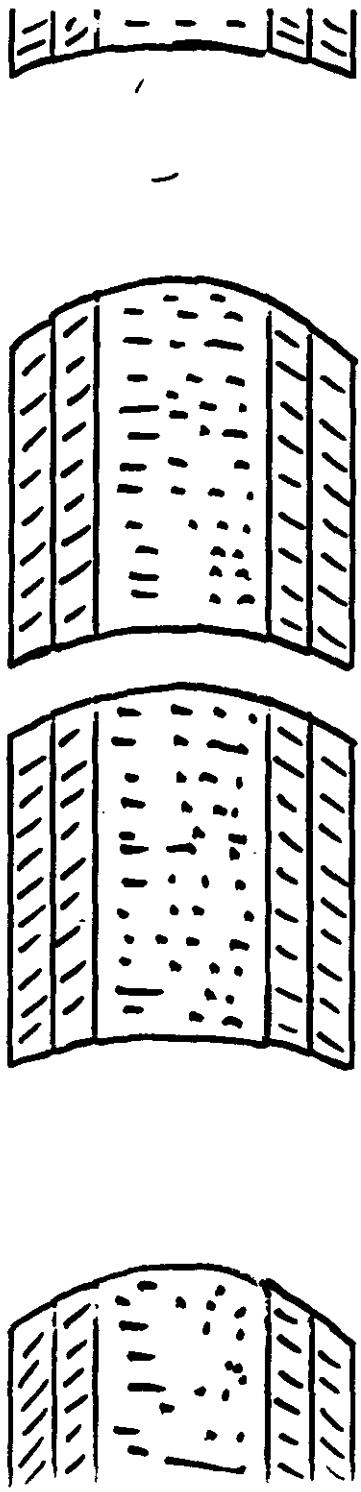
* POSSIBLE 'EVERY CASE' SOLUTION

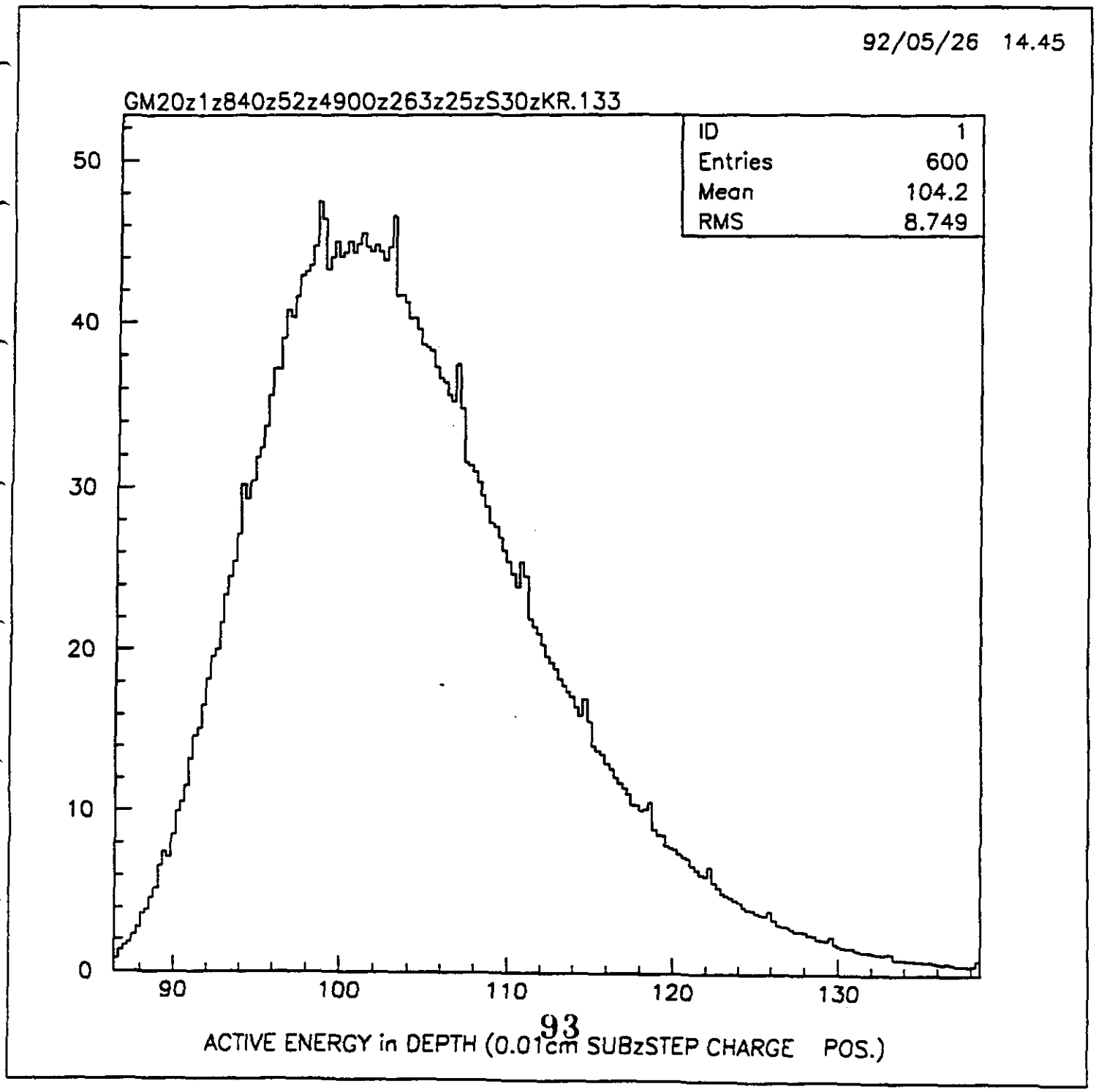
SPACERS IN THE CORNERS - ADDS RIGIDITY TO THE STRUCTURE WITHOUT ENERGY RESOLUTION DETORIATION

20 GeV ; 100 keV CUTS ; SUBSTEPS = 100 microns

SPACERS [mm]	MEAN ENERGY IN ACTIVE MEDIUM [GeV]	RESOLUTION (+/- 0.2)%
NO	6.832 +/- 0.0036	5.29
1.25	6.699 +/- 0.0035	5.24
1.875	6.636 +/- 0.0035	5.27
2.5	6.576 +/- 0.0035	5.31

SPACER DIM: 1.25 mm
1.875 mm
2.5 mm




92/05/26 14.45
GM20z1z840z52z4900z263z25zS30zKR.133
ID 1
Entries 600
Mean 104.2
RMS 8.749
50
40
30
20
10
0
90
100
110
120
130
ACTIVE ENERGY in DEPTH (0.01cm SUBzSTEP CHARGE POS.)

gem

γeμ

Presentation by:

Y. Kamyshkov

Yu. Kamyshkov

Present major activities in Calorimetry

1. Formulation of the new Baseline II

2. Formulation of response to Exec.Committee requirements about e-m option:

   a) Liquid ionization technique : viable design and beam test results

   b) BaF_2 : radiation resistance, uniformity, calibration etc.

Calorimetry Progress Report

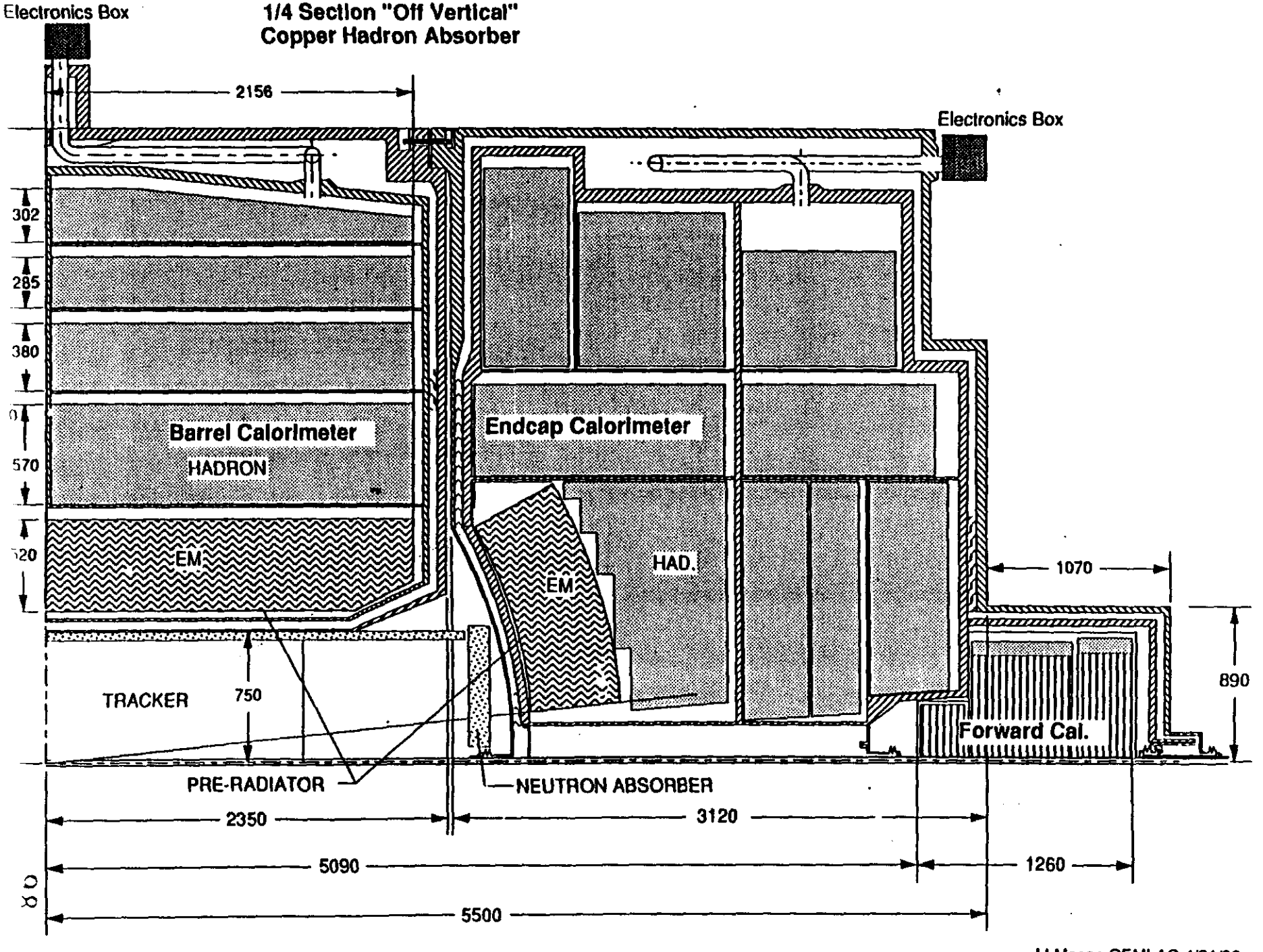
June 4, 1992, GEM meeting SSCL

1. Projective accordion simulations	M.Seman	20′
2. Hybrid Option -> new baseline	Yu.Kamyshkov	10′
3. Progress in SSCintCAL hadron calorimeter	L.Sulak	10′
4. BaF2 radiation resistance, mechanics, coating	H.Newman	20′
5. BaF2 production news	R.Y.Zhu	10′

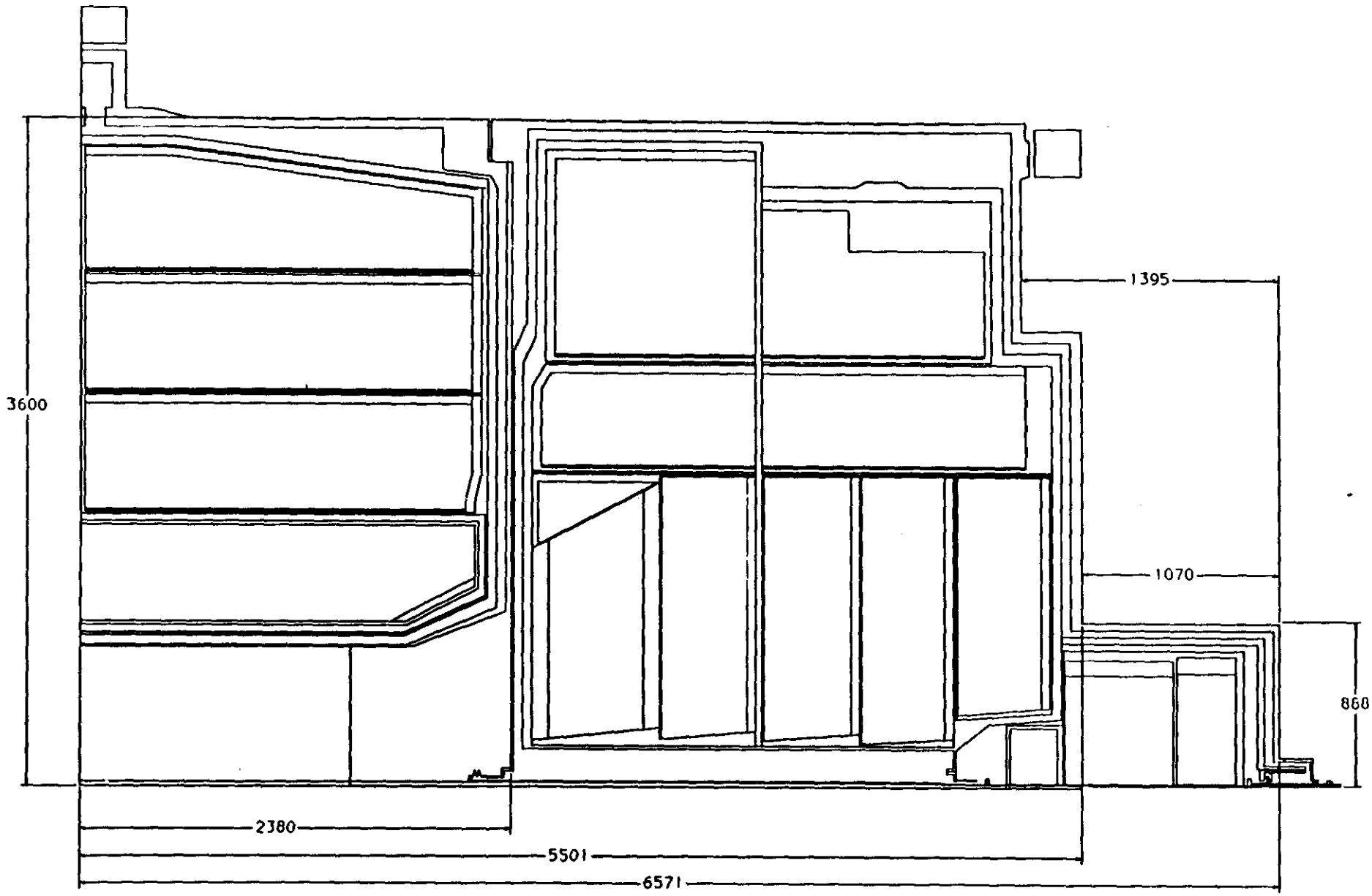
GEM Liquid Argon Calorimeter

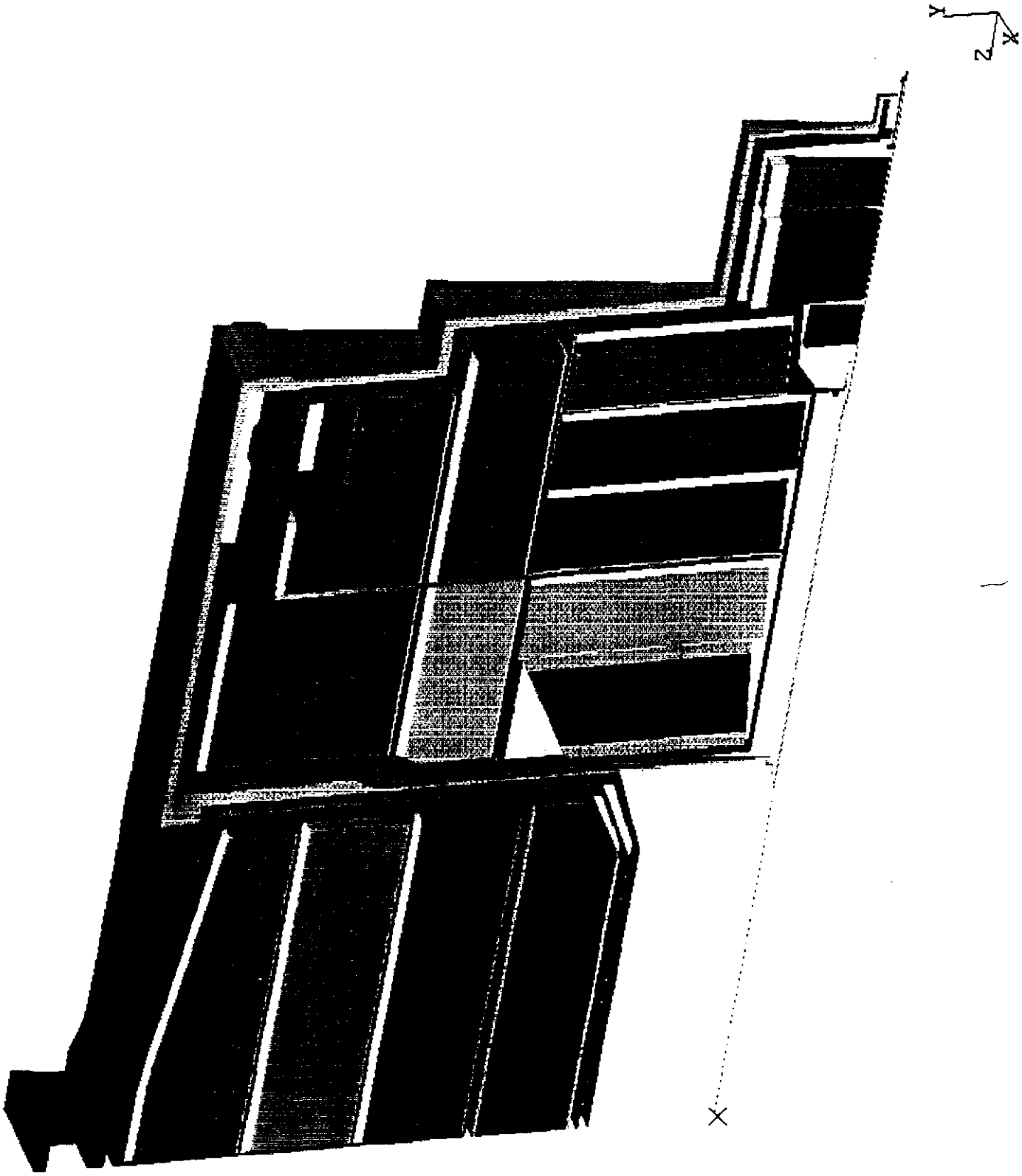
Baseline 1

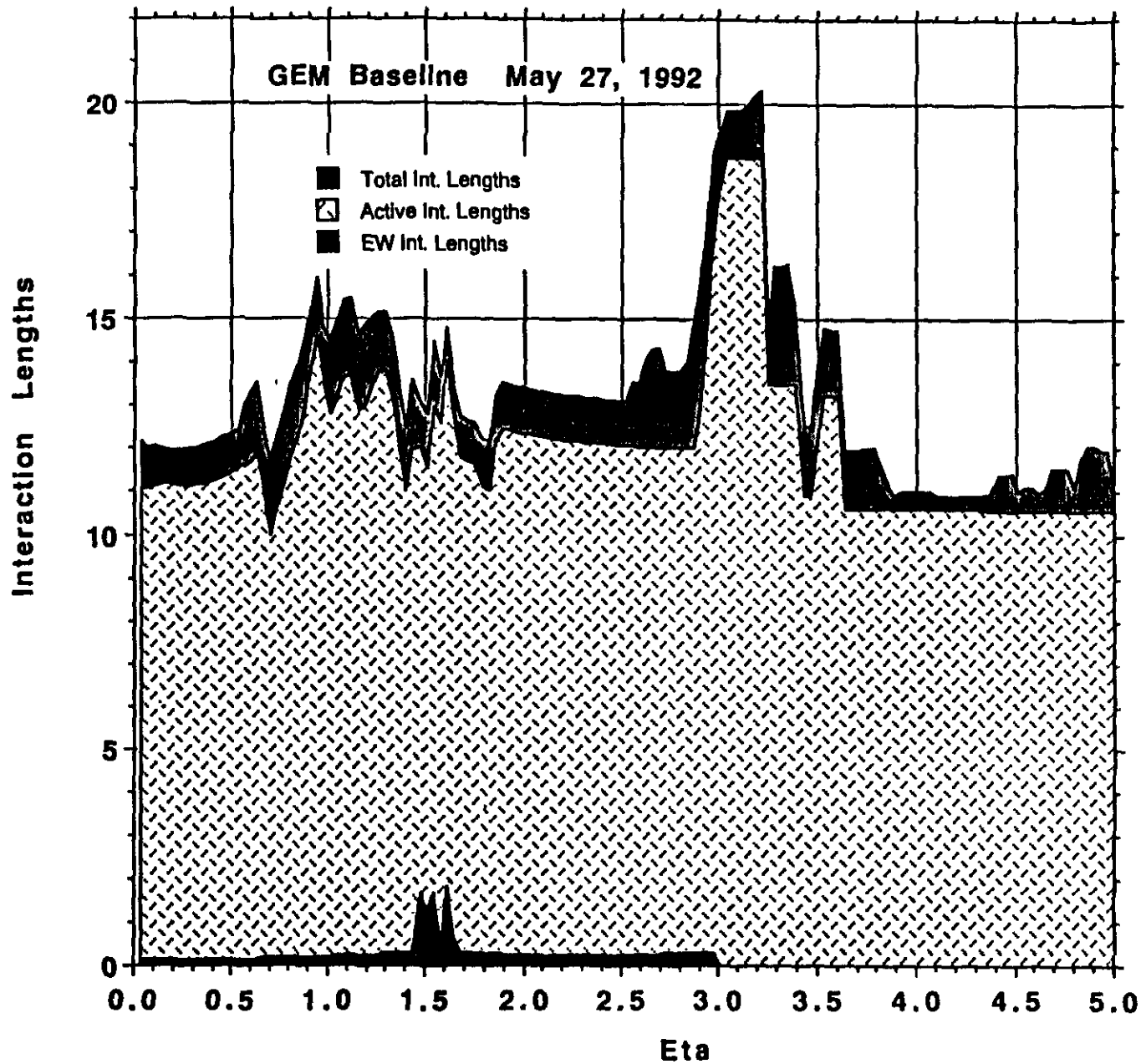
1/4 Section "Off Vertical"
Copper Hadron Absorber

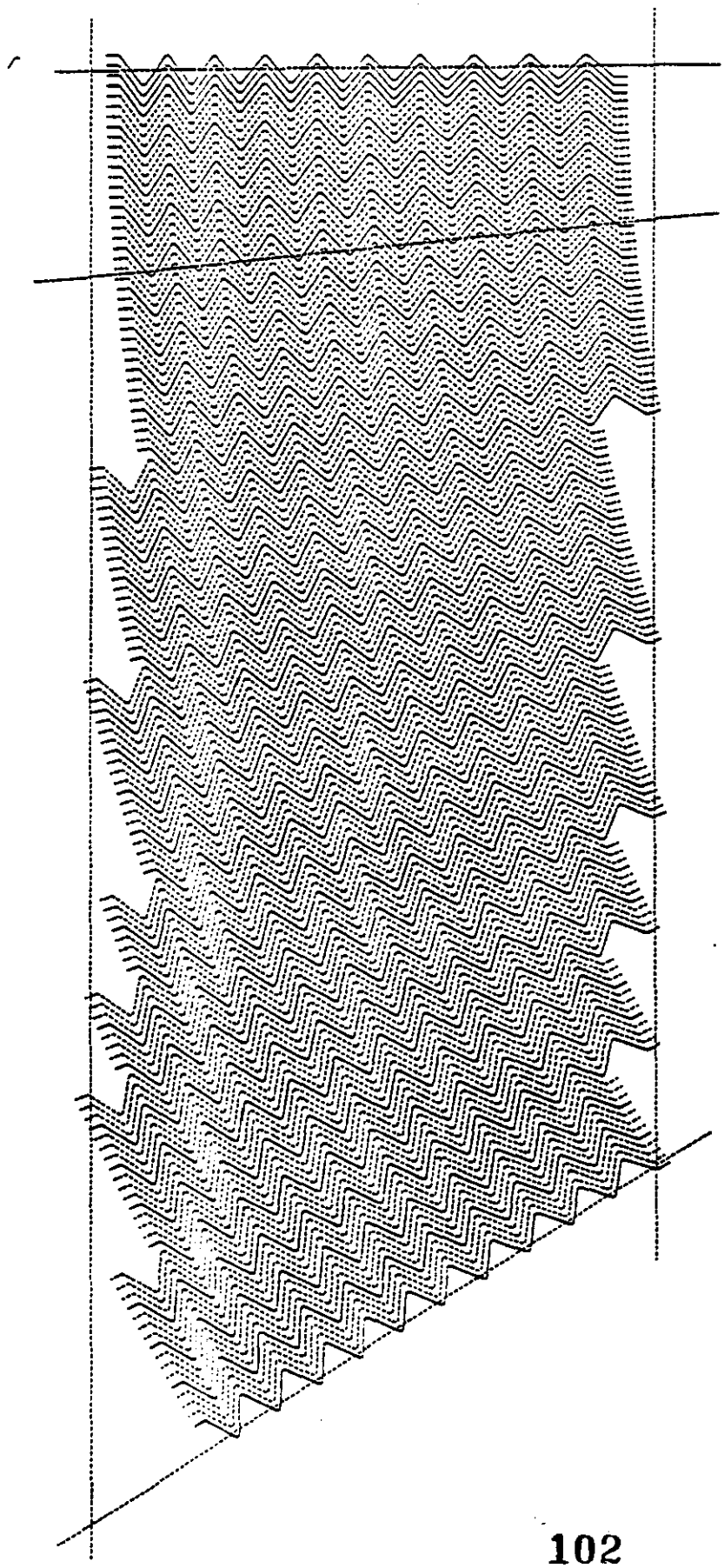


LLMason GEMLAC.4/21/92


3600
1395
1070
868
2380
5501
6571


Y
Z
X


GEM Baseline May 27, 1992
Total Int. Lengths
Active Int. Lengths
EW Int. Lengths
Interaction Lengths
0
5
10
15
20
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
Eta



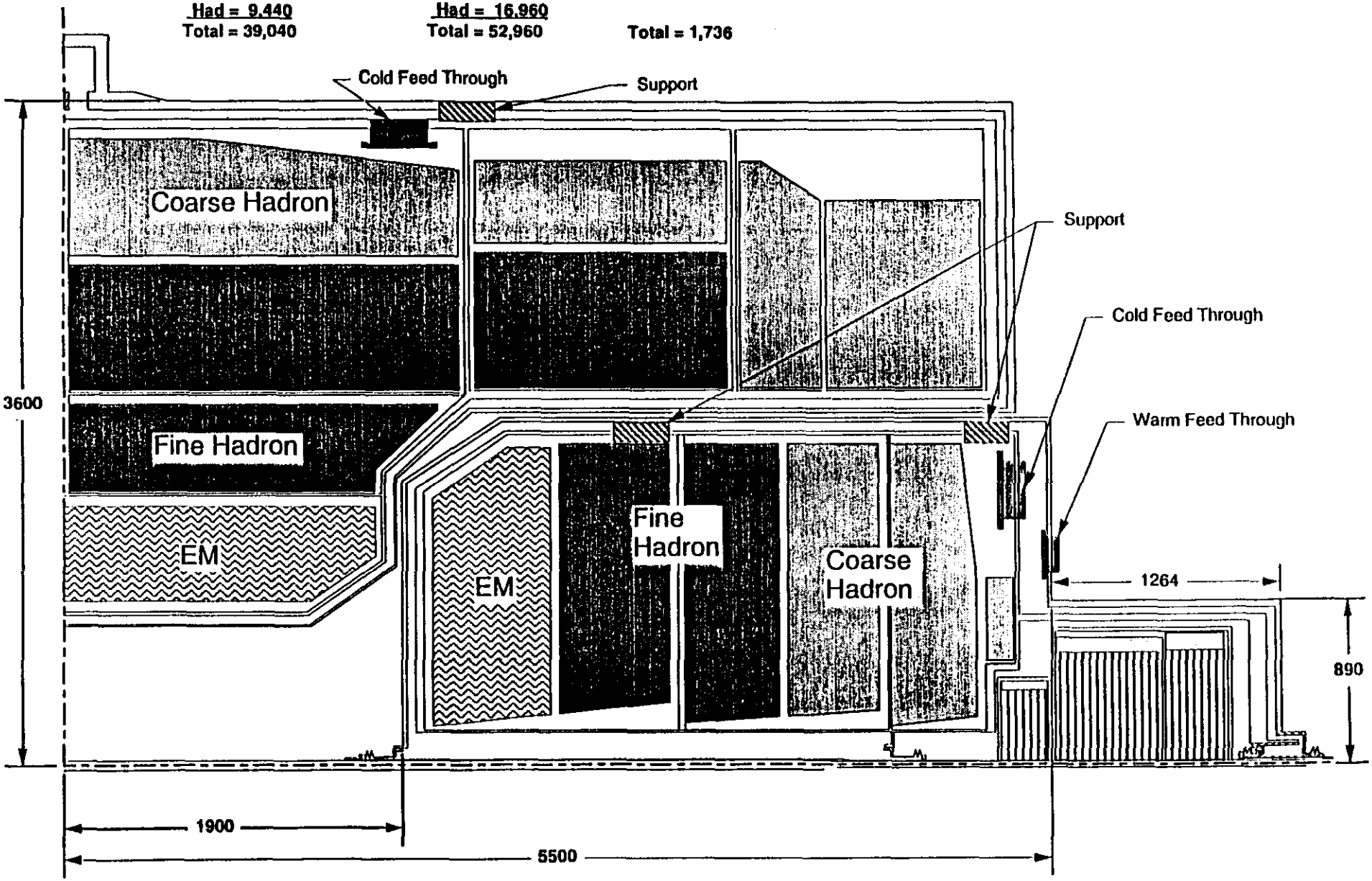
Liquid Argon Plug Calorimeter

- Weight = 2011 MT

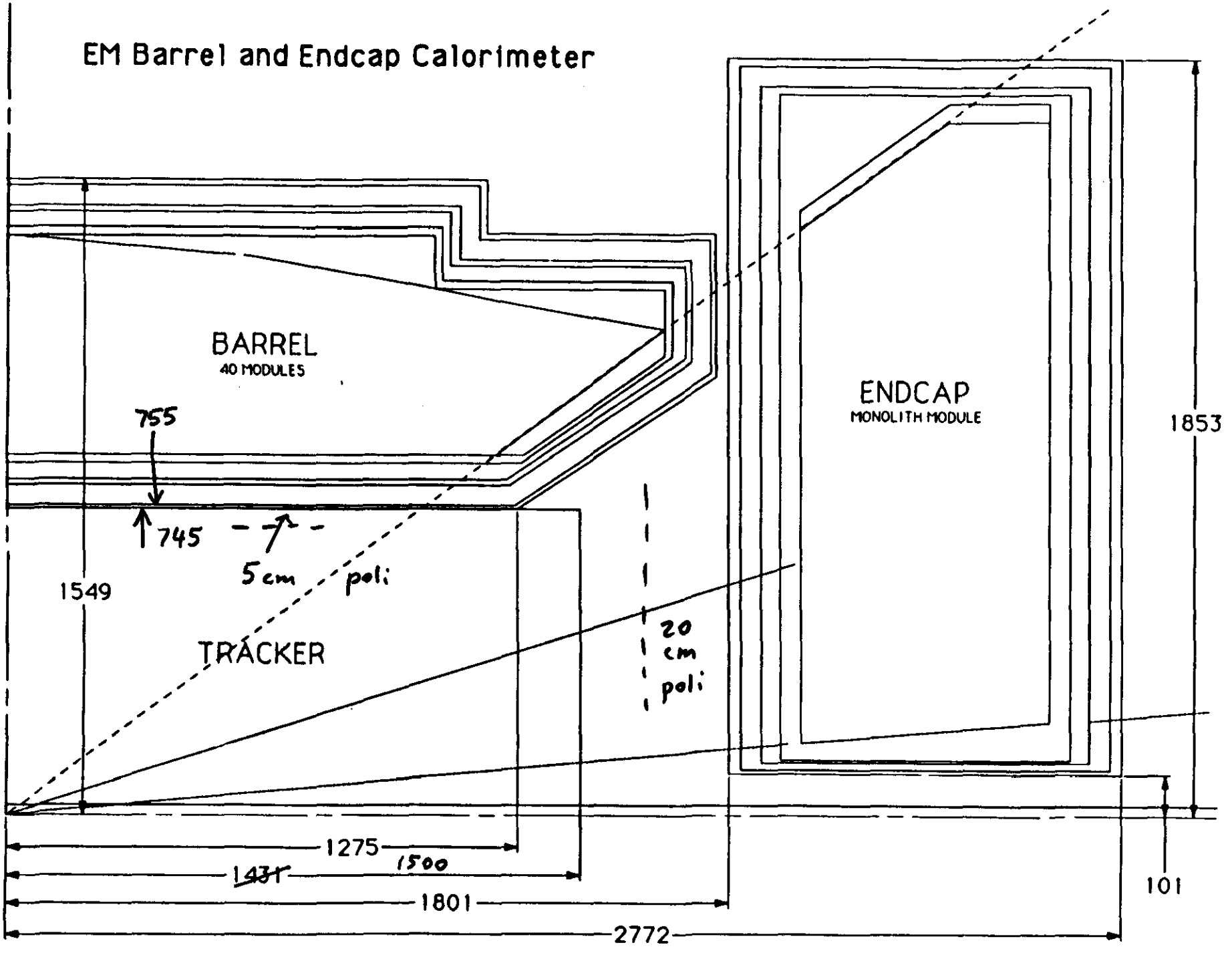
- **Barrel Channels**
  EM = 29,600
  Had = 9,440
  Total = 39,040

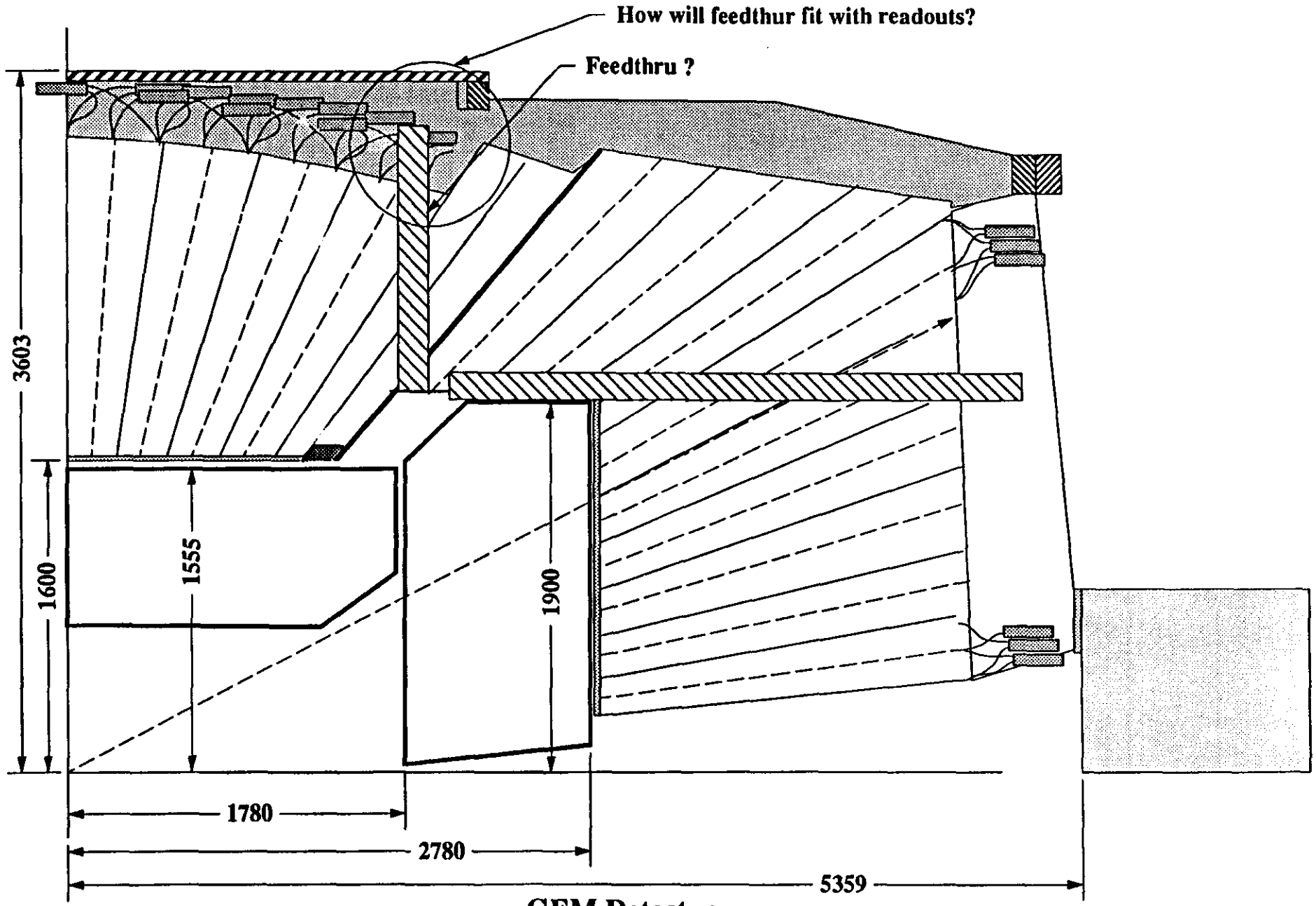
Plug Channels
EM = 36,000
Had = 16,960
Total = 52,960

Fwd Cal Channels
Total = 1,736



KBarnstable GEMLAC.Plug 5/26/92

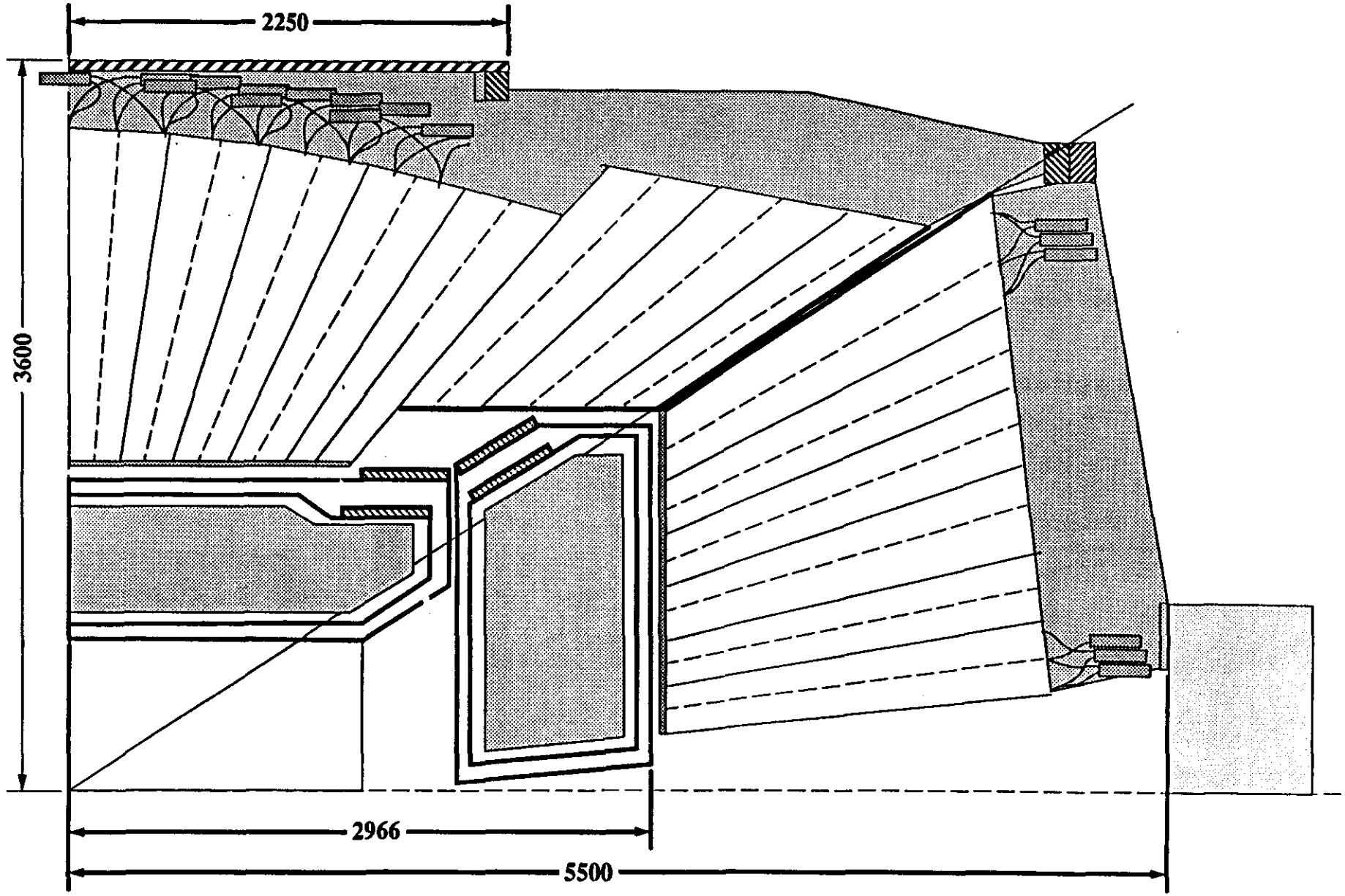

EM Barrel and Endcap Calorimeter
BARREL
40 MODULES
ENDCAP
MONOLITH MODULE
TRACKER
755
745
5 cm poli
20 cm poli
1549
1853
101
1275
1500
1431
1801
2772



GEM Detector
Fiber Hadron Calorimeter
Fiber with Current LAr Design

G.03.CU.043

Rennich
May 25, 1992

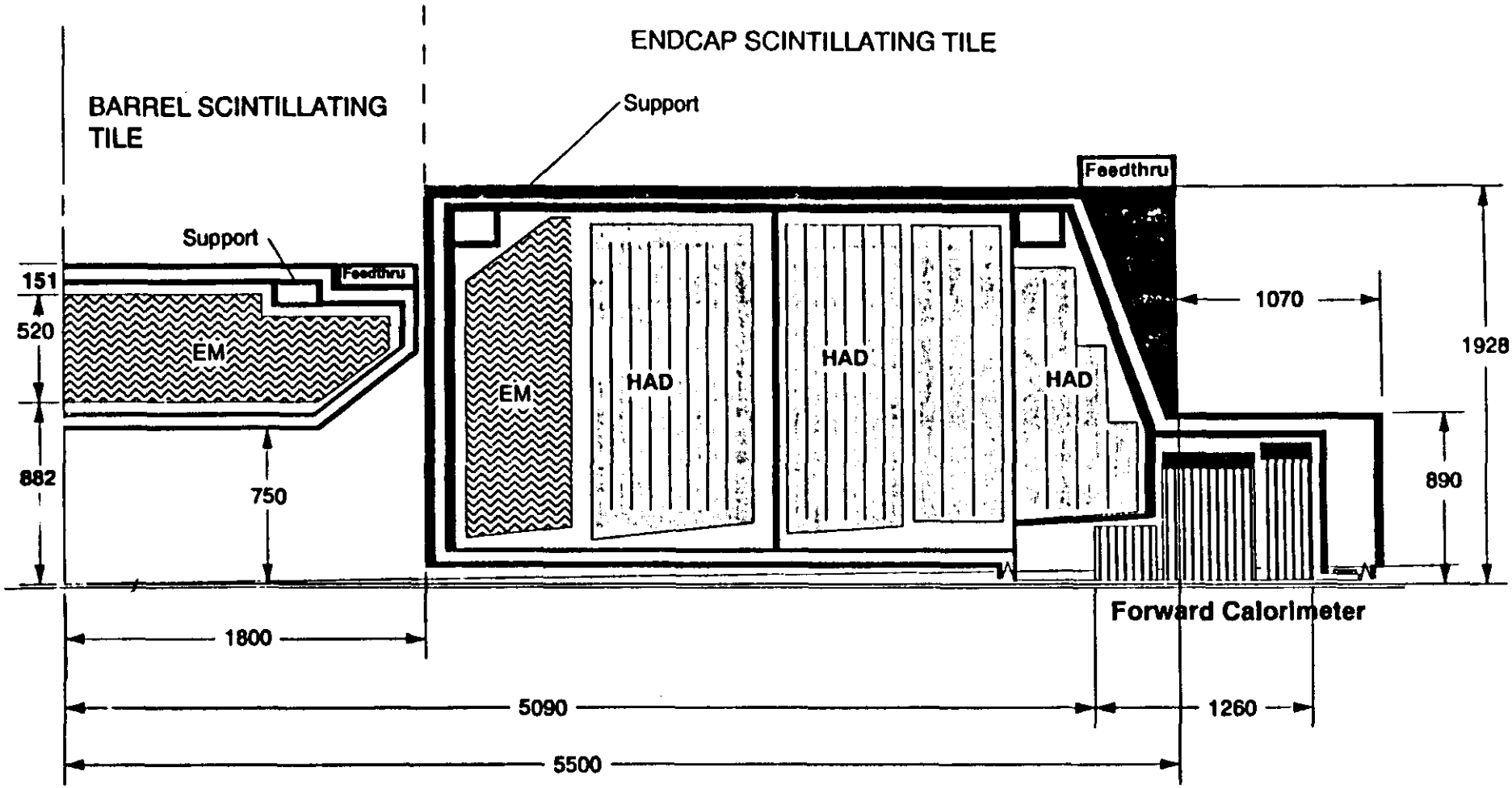


GEM Detector
Fiber Hadron Calorimeter
Fiber with Current LAr Design

G.03.CU.043

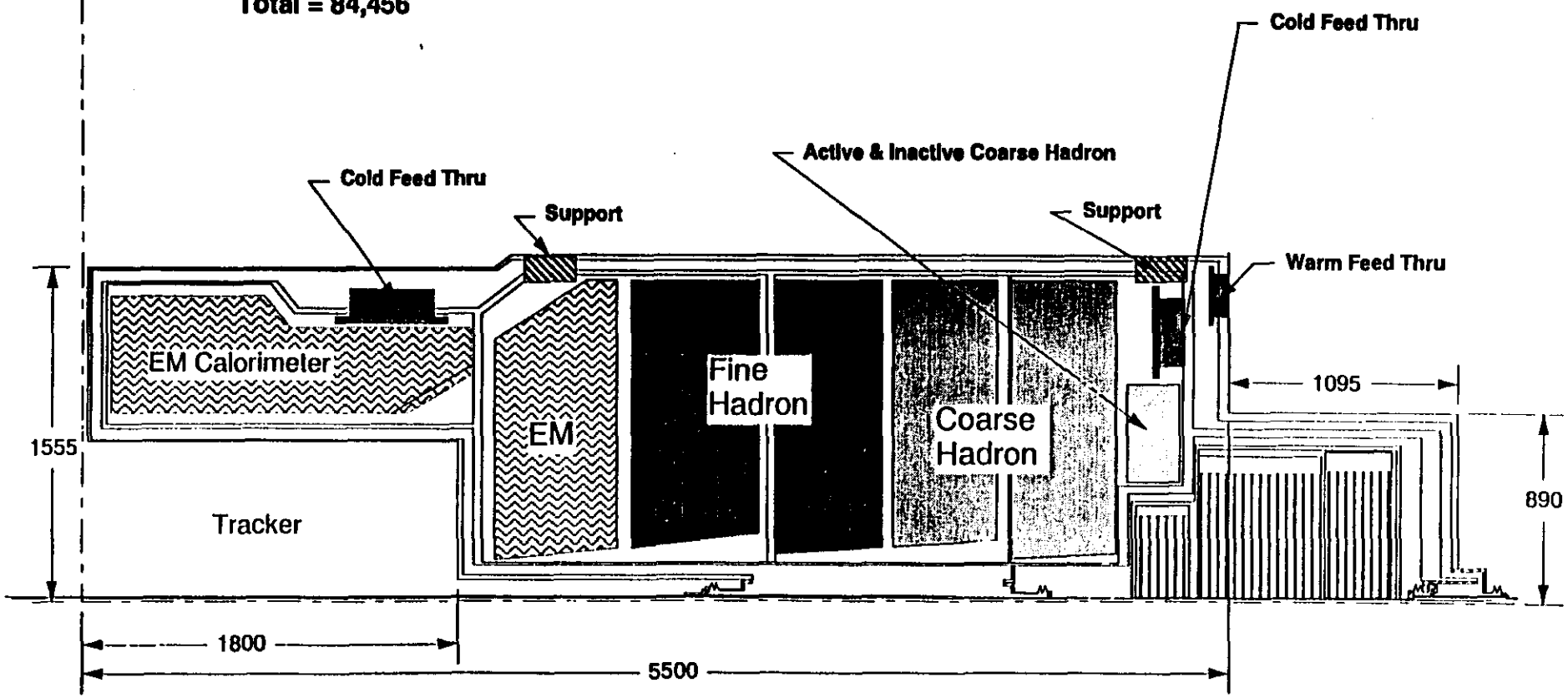
Rennich
May 28, 1992

BARREL/ENDCAP EM - LIQUID ARGON PLUG-TILE ENDCAP

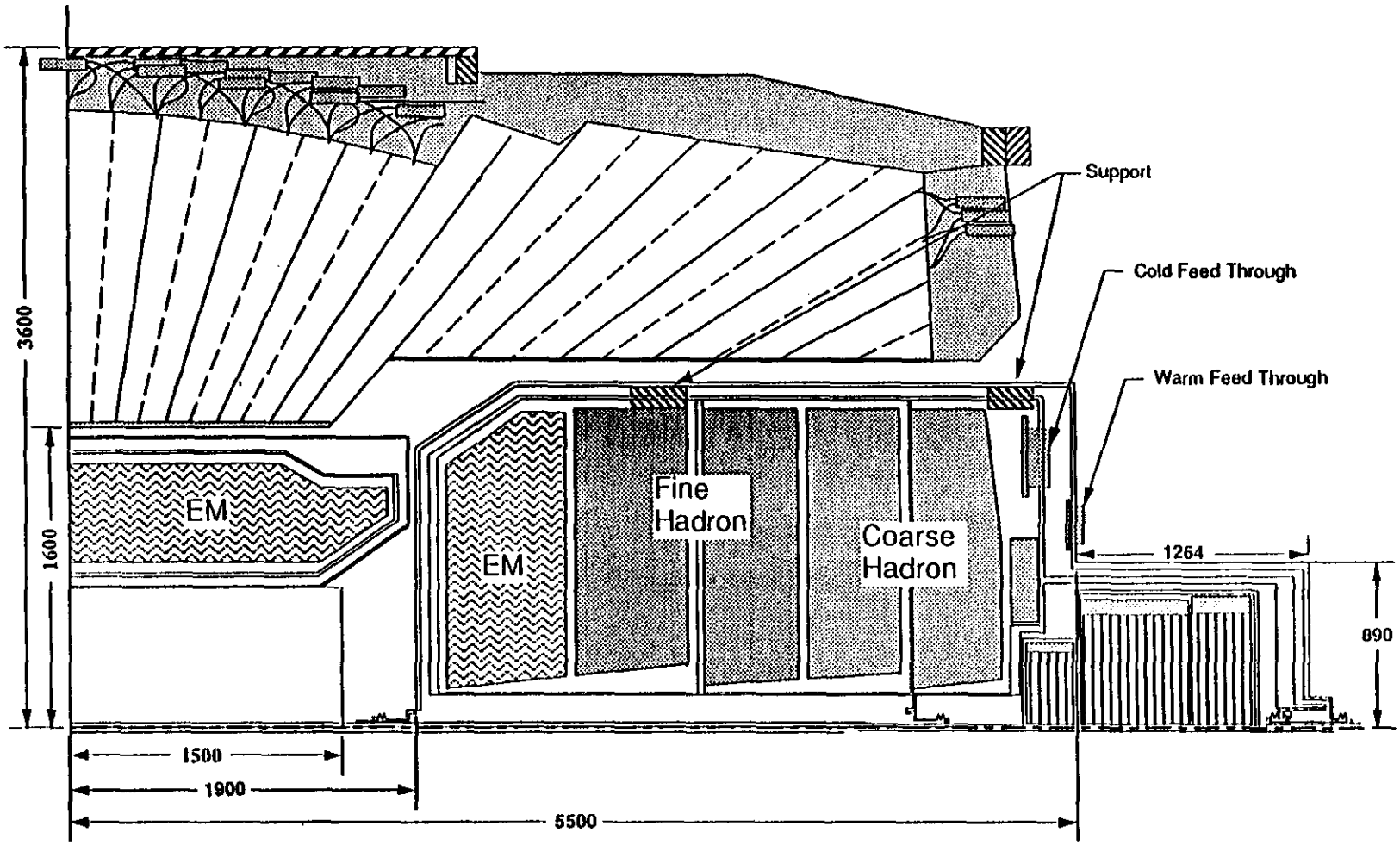


EM and Hadron Plug - Center Split

- Weight = 282 MT
- No. of Channnels
  - EM = 66,400
  - Had = 16,320
  - Fwd = 1,736
  - Total = 84,456



KBarnstable GEMLAC.Plug Ctr Split 5/29/92



GEM Detector
Fiber Hadron with LKr EM Calorimeter

gem

γeμ

Presentation by:

L. Sulak

RECENT PROGRESS ON SSCintCAL HADRON CALORIMETER

L. Sulak

GEM Collaboration Council Meeting

June 4-5, 1992

SSCintCAl Hadron Calorimeter

Status Report June 4, 1992

(1) Number one prototype tower completed. Beam test table electronics etc. all ready and tested, easy rigging in and out of shop.

(2) Proving technology. Optimizing manufacture for GEM. { tubeless design, tellurium copper extrusions

(3) All techniques "teachable" to offshore technicians in U.S. All tooling & equipment shipped from U.S. Engineer from U.S. resident on site. Periodic monitoring and quality control with reports by E-Mail.

Near Term Schedule

#2-4 being machined - various stages

June 5 #1 mechanically done with fibers in

June 9 #1 has PM, mixer, base, etc installed

June 12 #1 tested light tight

June 13-14 ship to BNL - rig in

June 15-16 1st results #1

⋮

July 7 #2 to #5 to BNL, minimum
to #7 ideal goal

July 15 Test beam off

potential hangup: machining off step function

SSCintCAL Hadron Calormeter

7 Prototype Towers

Status Report June 4, 1992

W. Worstell

Mechanical test of first tower (hammer & chisel.
Tower holds together well.

Stuffing fibers into tower will be completed today.

New hex clamp holds fiber bundle prototype well.
Drawings prepared and submitted to shop, 17 being made (7 towers, 2 tower mockups, 1 4-tower mockup, and 4 spares).
(Mike Brooke, University of Mississippi, machinist)

First version of PMT mounting structure in progress.
Spring-loaded for Silastic joint.

Light mixer completed by MSU.
Six more ordered.

Expect to ship tower to BNL by next weekend.
Beam test scheduled before June 17 & 18th, "BNL Calorimeter Meeting".

Modification of three inch PMT design.
100 "tail-catcher" fibers bundled to one inch PMT in progress.

SSCintCAL Hadron Calorimeter

Sequence for Construction of Prototype Towers

Photo Captions

1. Station 1 - Mill-run plate in fixture on a ball pad, fordrilling hold-down bolts and alignment pins. Plate under far drill press.

2. Stations 1 & 2 - At right is Station 1 with plate being drilled. Station 2 is at left, ready to accept drilled plate from right.

3.&4. Station 2 - "Gang" milling array of parallel grooves with square cross section, lubricated by "Marvel Mystery Oil". Allows approximately twice volume removal relative to standard cutting oil.

5. Station 3 - The blur is a technician cleaning the plates. Degreasing milled plates with ionic detergent "Alconox", standard labware cleaner.

6. Station 4 - Shearing grooved plates to final trapezoidal shape. Hold down holes of one edge trimmed off. Others await trimming.

7.&8. Station 5 - Tubes inserted in grooves of first plate of tower. Tubes are pushed against stop for uniform protrusion on large (far) end. (In photo 8, remnant holes a relic of too narrow of mill order plates (this run only).

9. Station 6 - Stacking plates on assembly fixture and applying solder/flux paste (Nocorrode Liquid Solder).

10. Station 6 - Stack approximately 1/2 assembled on assembly fixture.

11. Station 6 - Checking alignment of layers with straight edge.

12. Station 6 - Completed lay-up of stack. Ready to apply clamps to load to specified pressure.

13. Station 6 - Applying clamps and loading by compressing springs under nuts. Max load approximately 300#, each spring, when fully compressed.

14. Station 6 - Small end view. Last 2 clamps not yet applied.

15. Station 6 - (cont.) Additional views of clamping procedure.

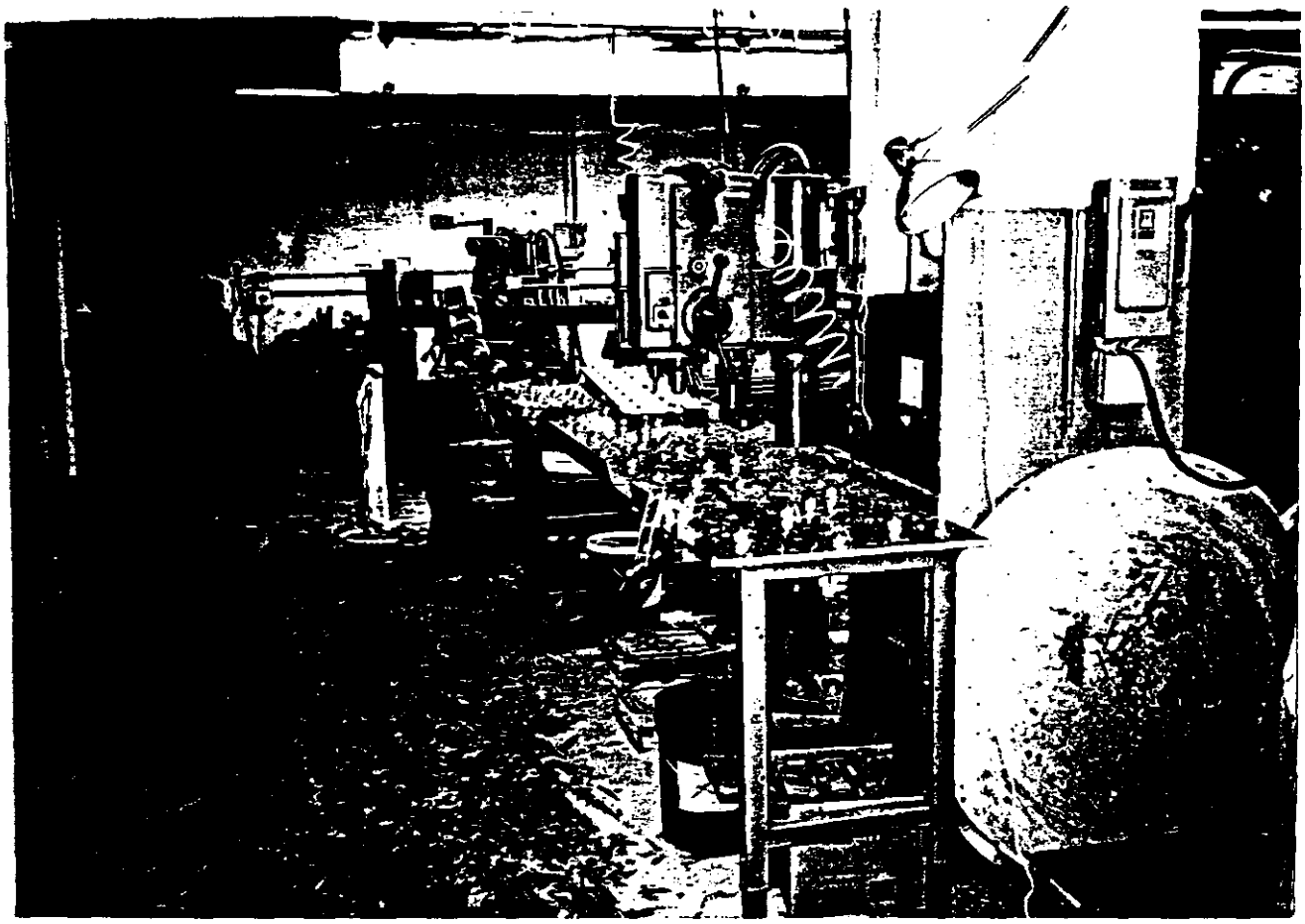
16. Station 6 - (cont.) Additional views of clamping procedure.

17. Station 6 - Inserting thermocouples in center and near edge of stack to monitor temperature during furnace soldering.

18. Station 7 - (Not shown). 500 degrees F for 8 hours; 8 hour cool-down.

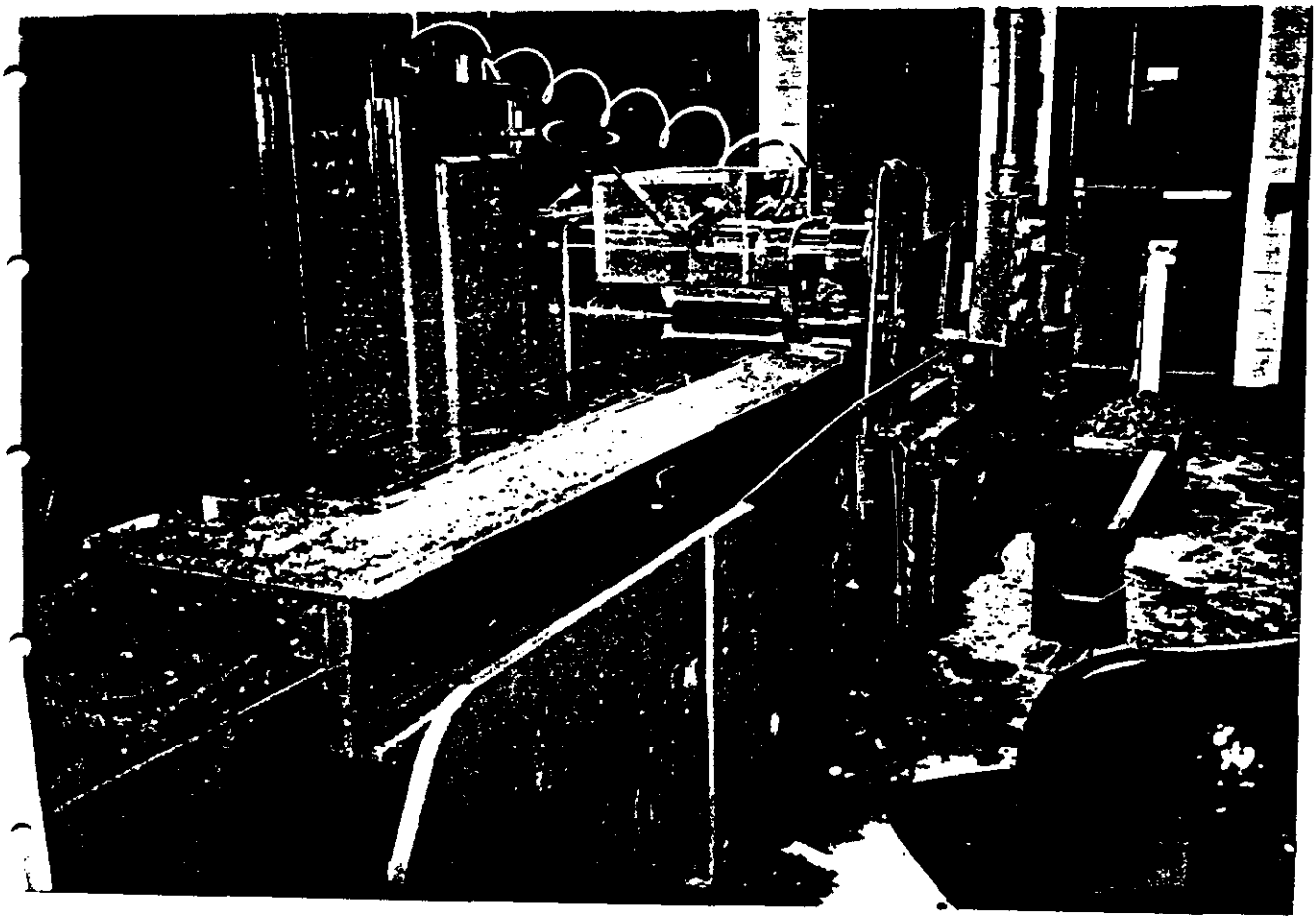
19. Station 8 - Completed tower stack assembly as returned from heat treating vendor. View of large end of tower, protruding end is mill finish of tubing as received from vendor. (clean and deburred).

20. Station 9 - (no photo) Tower machined to remove steps and remove off-center condition caused by one side grooving of plates.



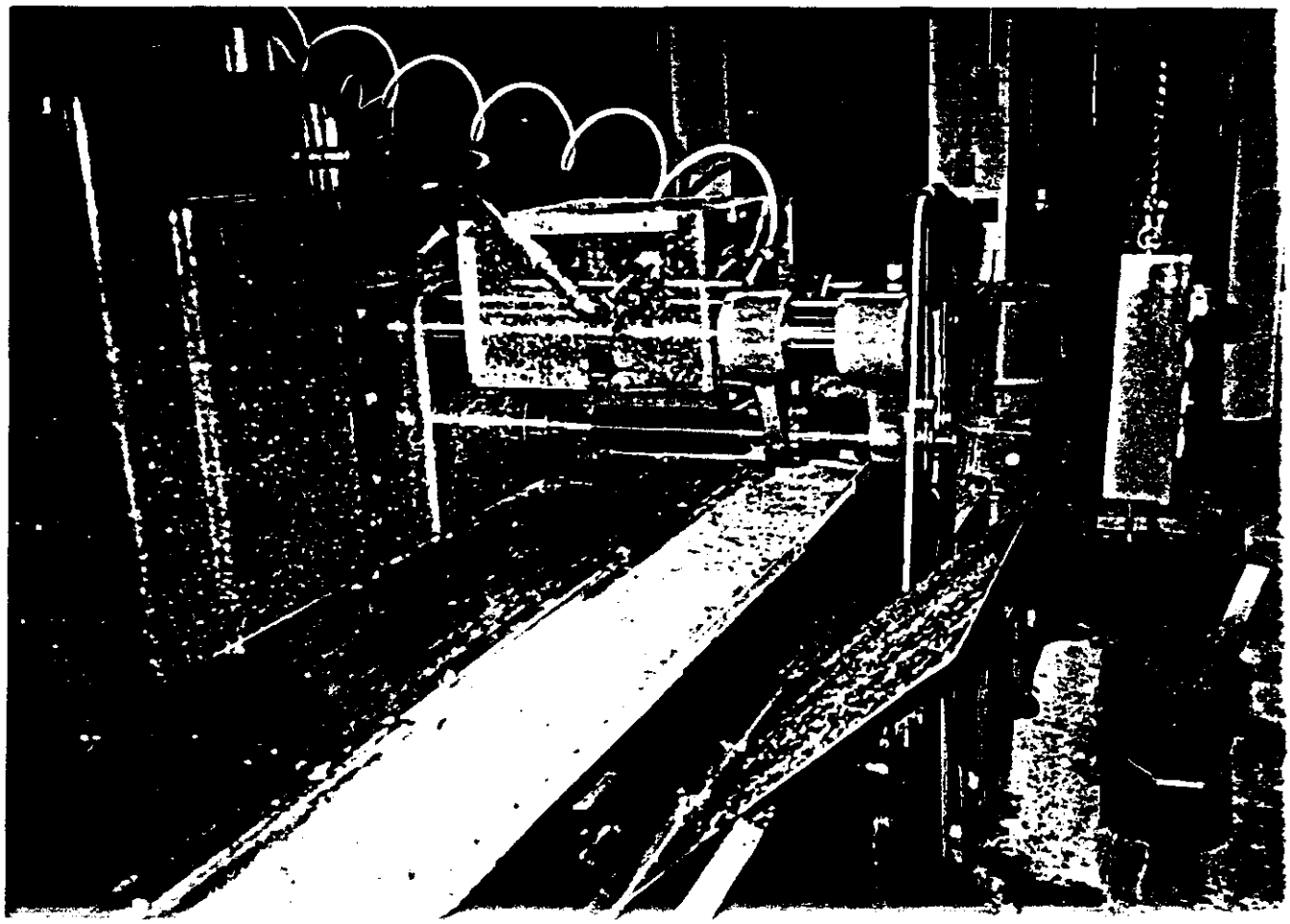
1

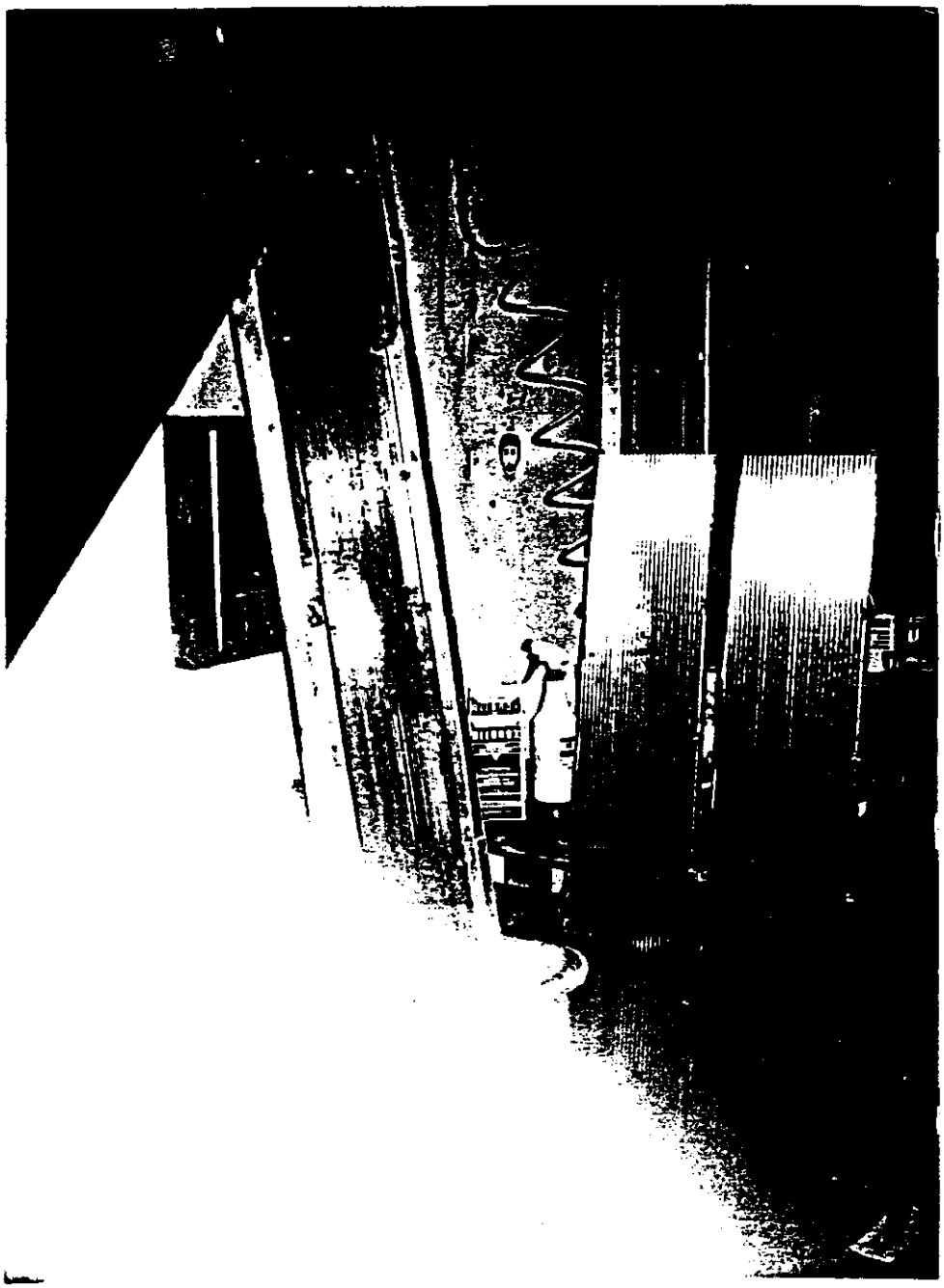
2



3

4





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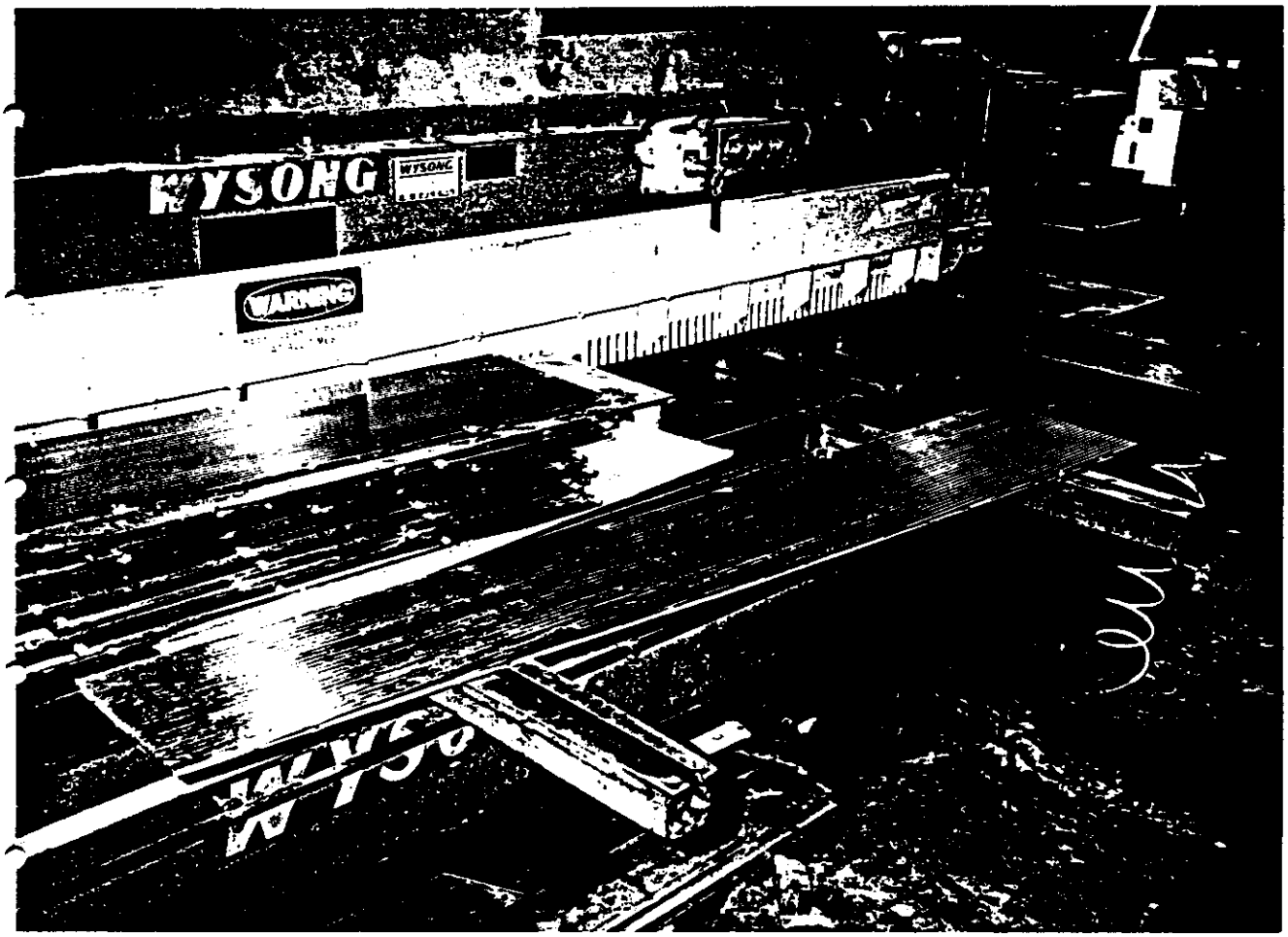

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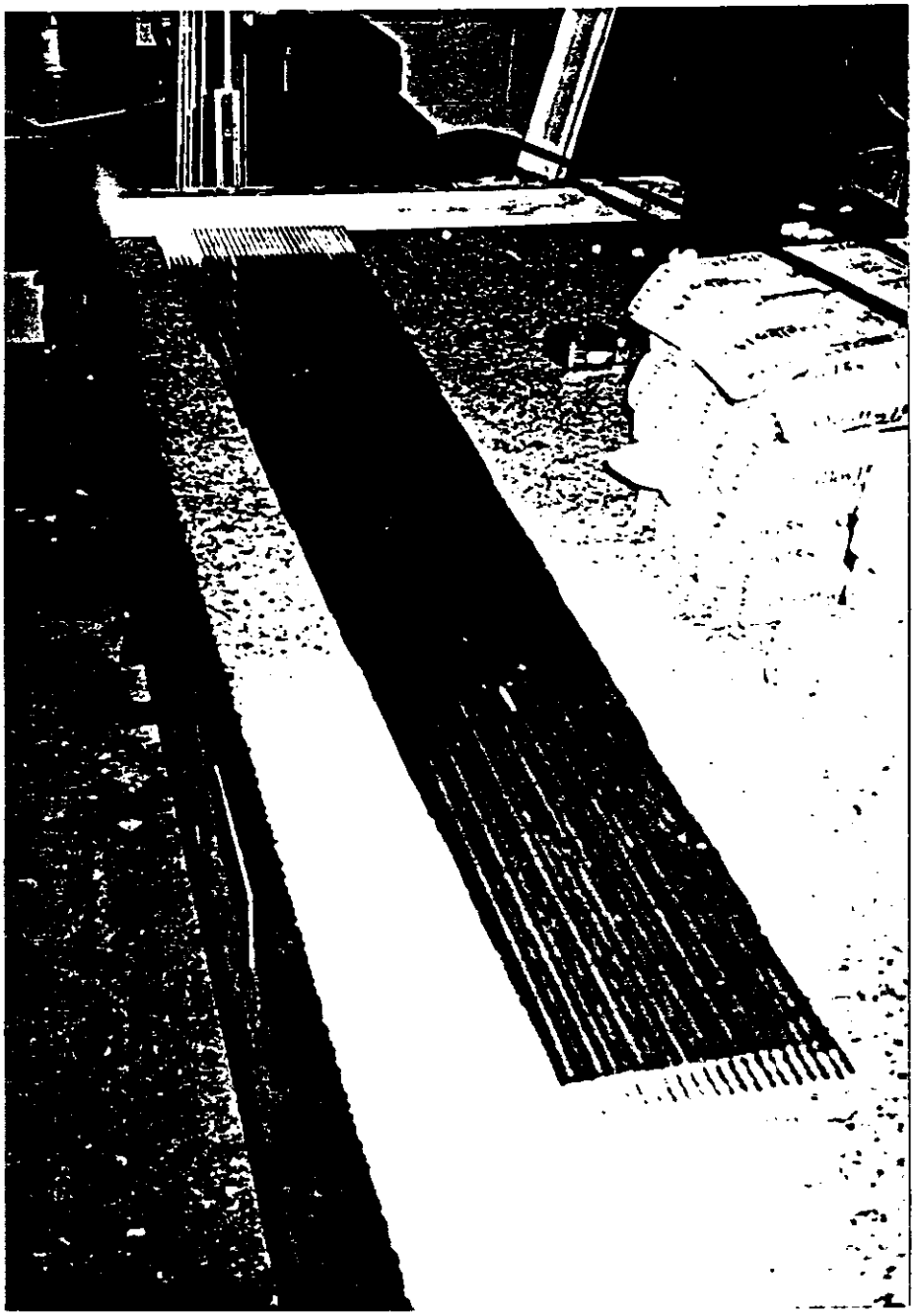

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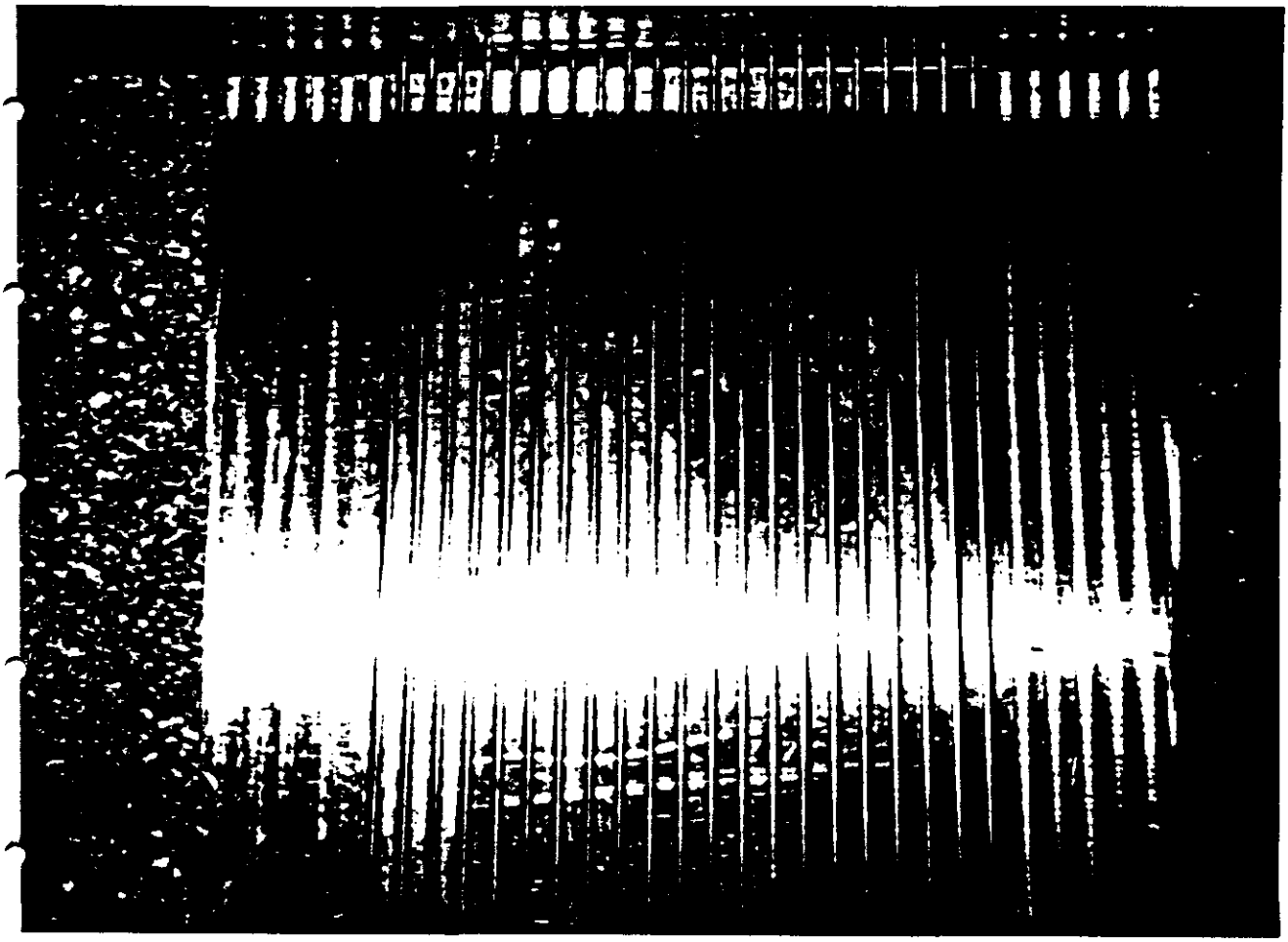

8

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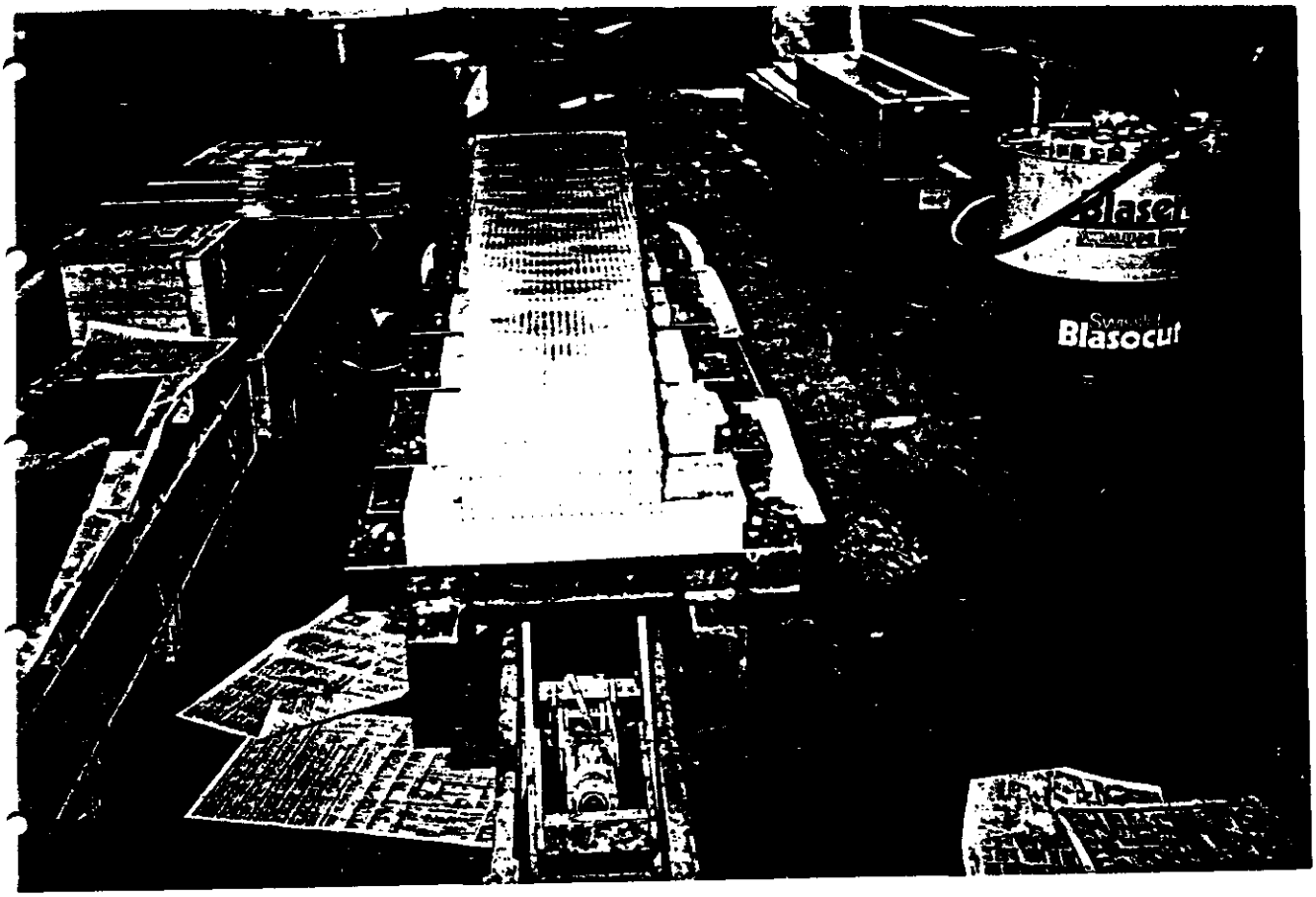
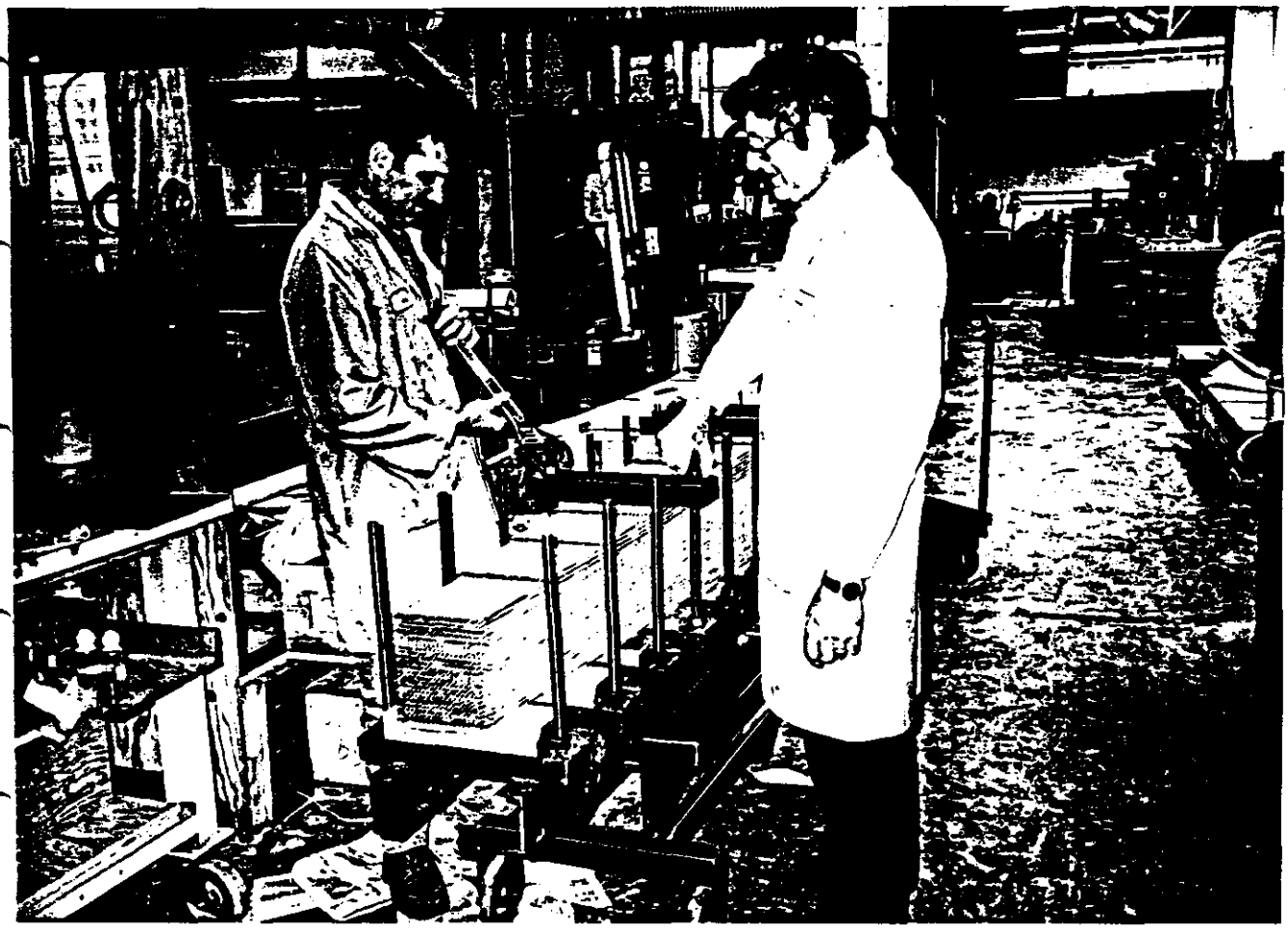


10

11

12



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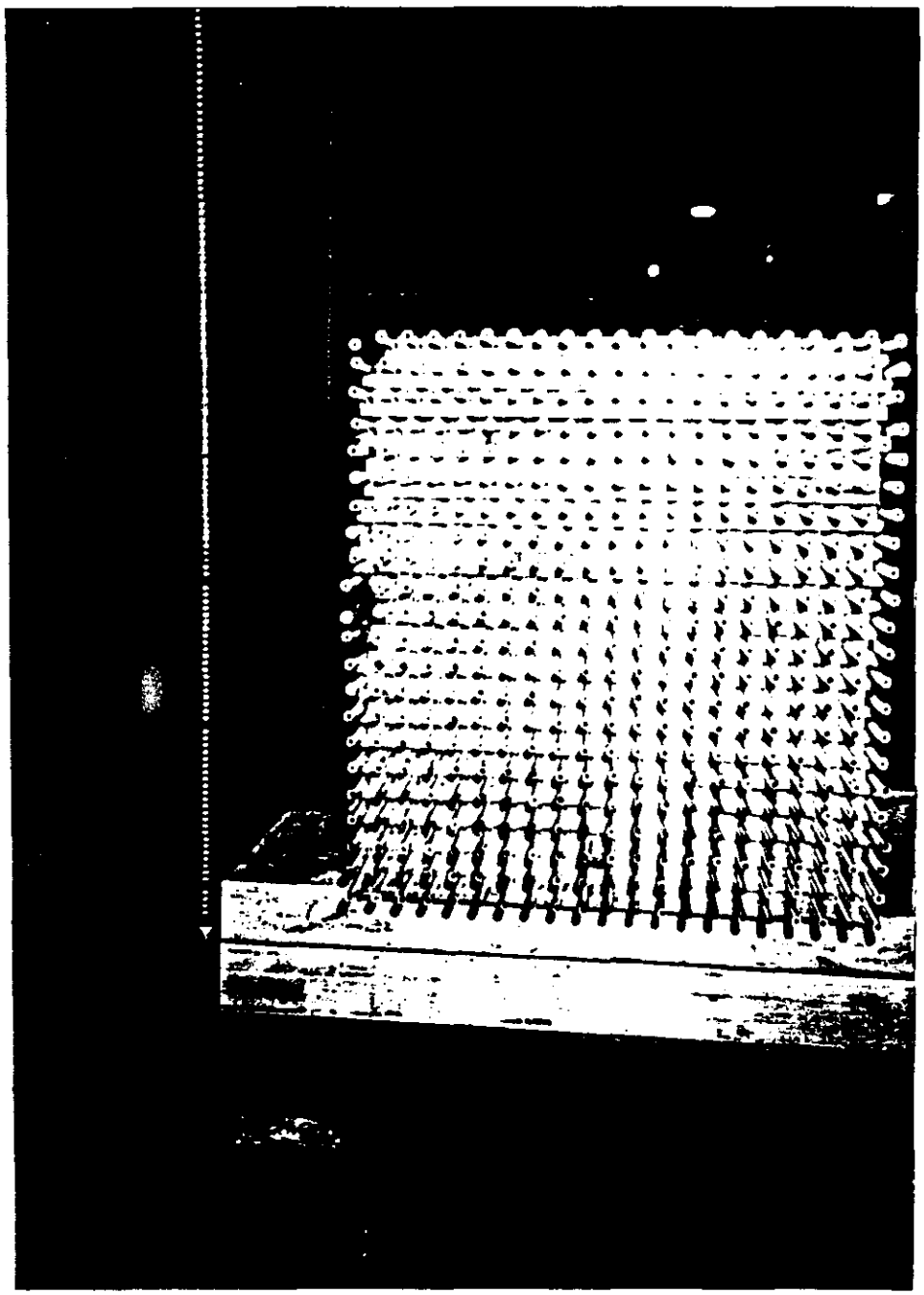

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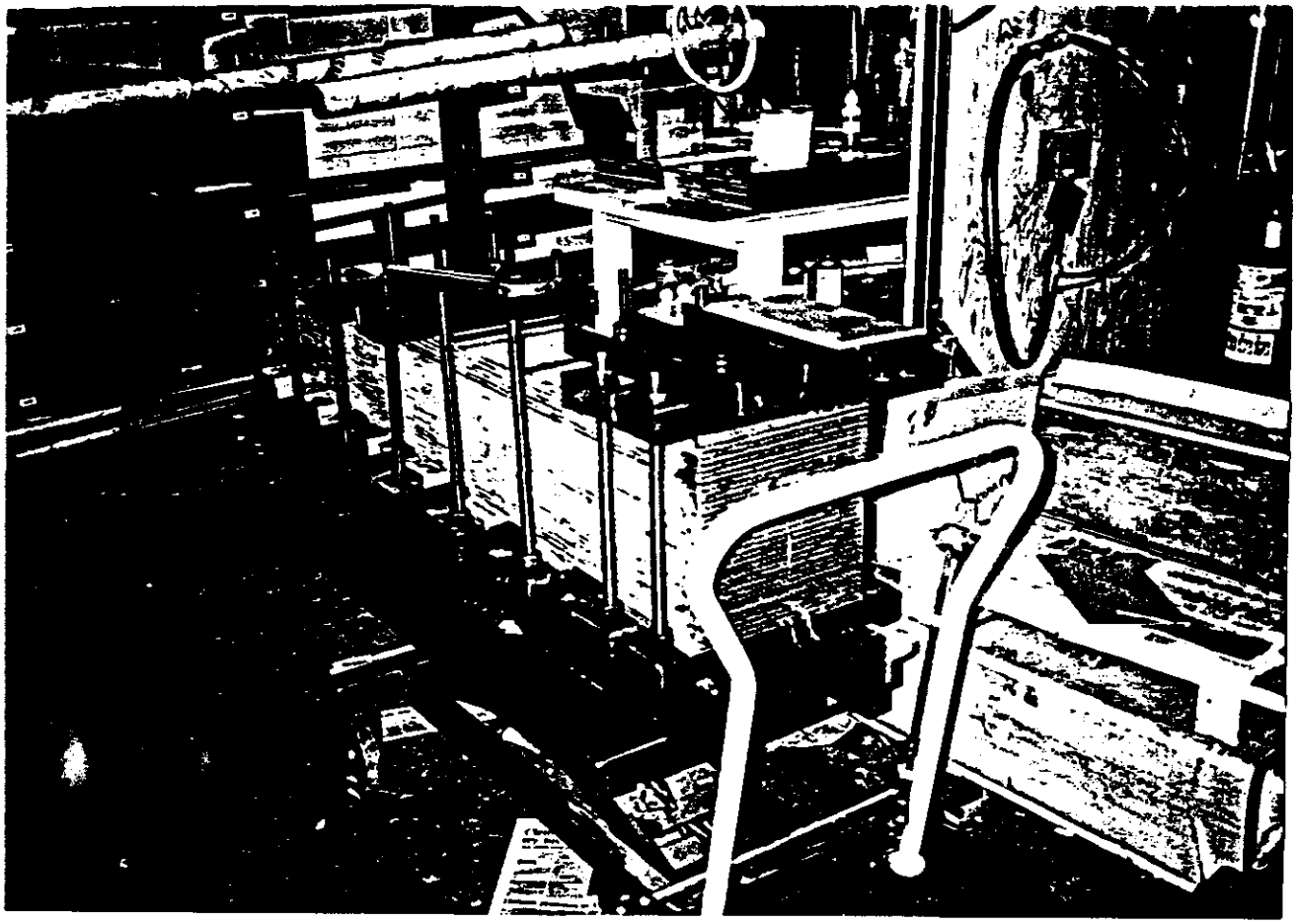
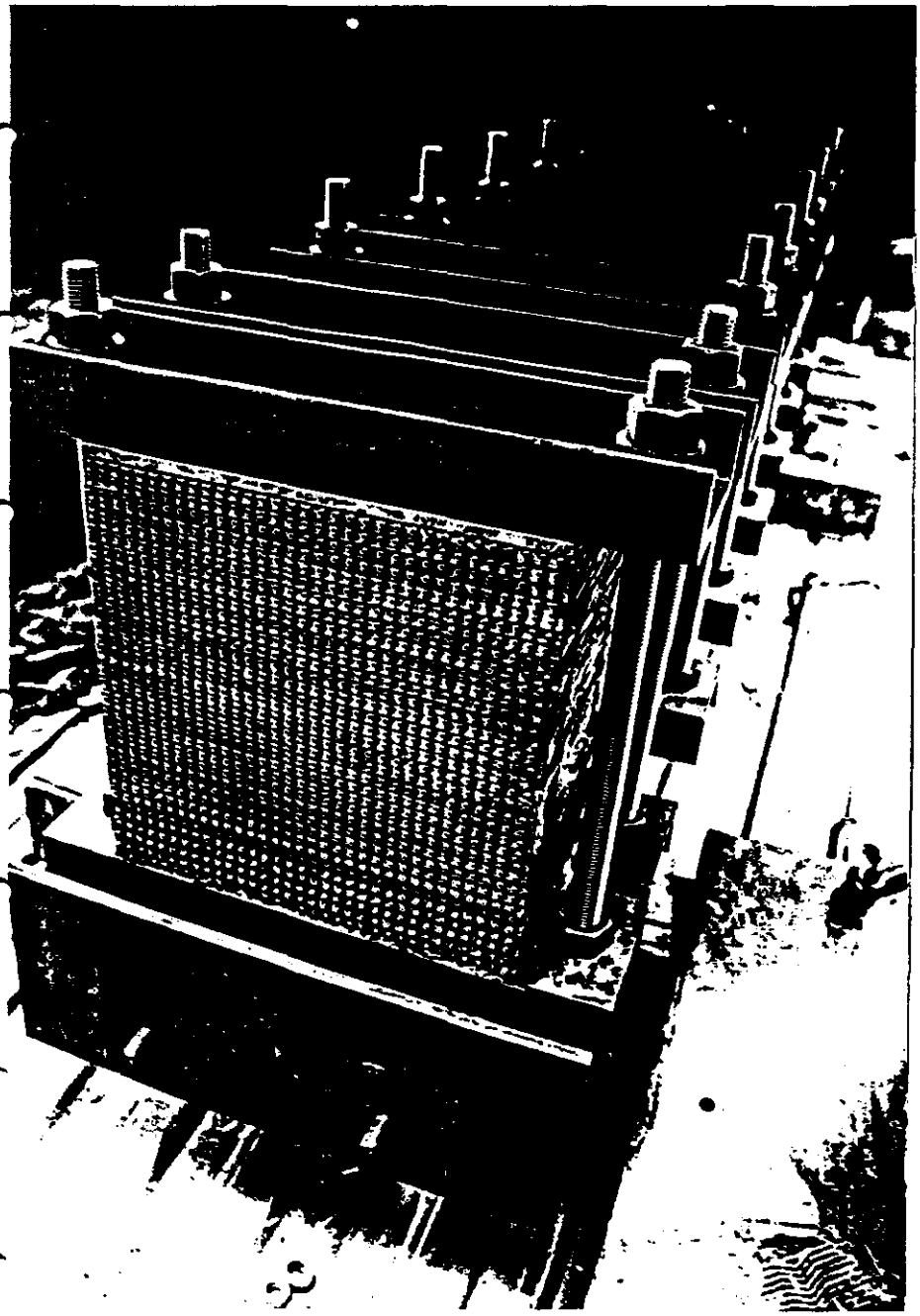


16

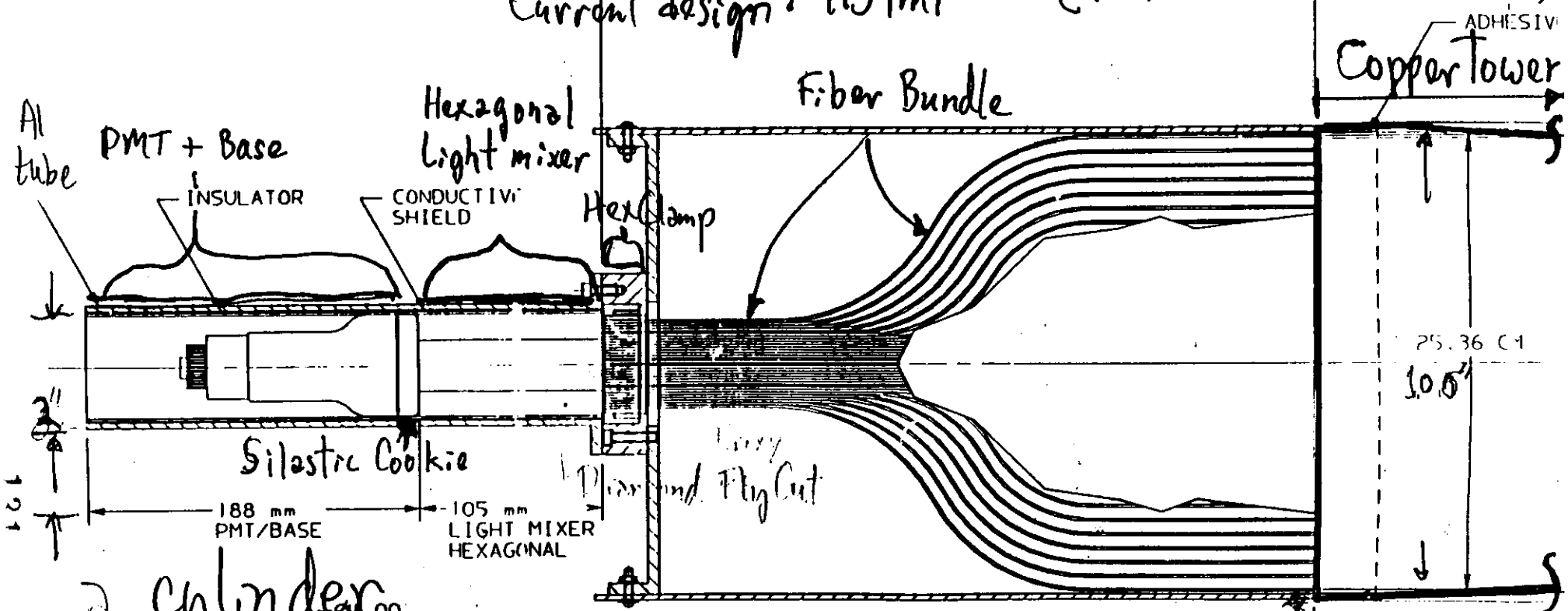
17



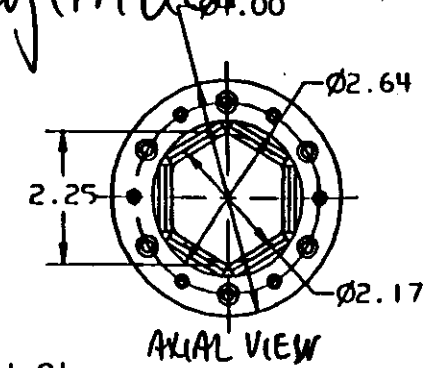
18

The Optical Package ... prototype simplified drawing

Current design: 1.5" PMT (1" PMT + 10% Fiber not shown)



... a cylinder



no finishing of big end

... a light-tight rectangular box

MAY 20 1992

PART NO. 292925

SEE PL

REV	
SHEET	

REVISION STATUS

INTERPRET DRAWING IN ACCORDANCE WITH 100-0-1000 LEVEL

DO NOT SCALE THIS DRAWING

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES

TOLERANCE ON DECIMALS ANGLES

MATERIAL

CONTRACT NO

DWN S FITZGERALD

CHK

APVD

APVD

ENGR APVD

APPROVED

DRAPER THE CHARLES STARK DRAPER LABORATORY CAMBRIDGE MASSACHUSETTS 02139

PMT L/O CALORIMETER PROTOTYPE TOWER

SIZE F | CAGE CODE 61993 | DRAWING NO 292925

Bob Reid (CAD) Steve Fitzgerald for 2" PM

OFF-SHORE PRODUCTION

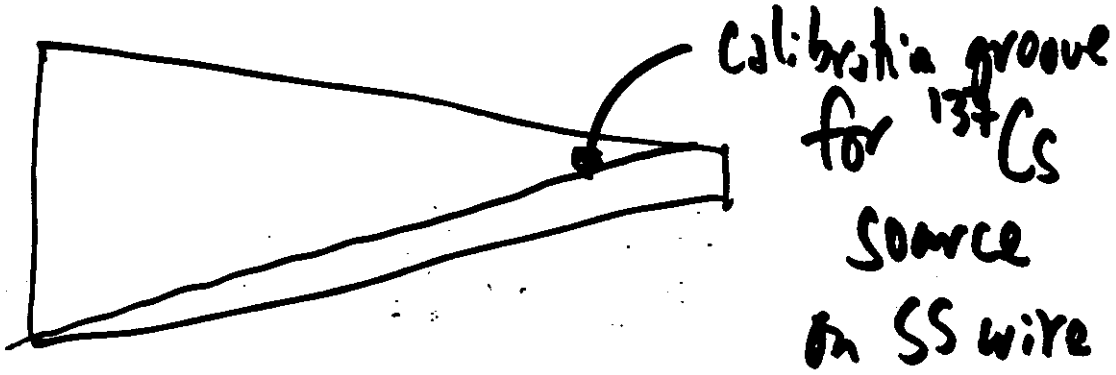
Albania - Copper absorber block production
Shipping to Equador

Equador - Insert fibers
Bundled fibers, attach PMT's, mount
Test
Ship (same container) to SSC

China - Alternate source copper blocks

Belarus - Quartz and plastic fibers
Electronics

India - Forward Calorimeter
200 GeV GEM dedicated test beam



Albania ...

[Paul Reardon (SSC & GEM)
Bob Sheldon's
Exploratory Trips,
Under Discussion:
Poland
Hungary
Slovakia

4 June 1992

Dr. Roy Schwitters
Director
National Accelerator Laboratory
Superconducting Super Collider
2550 Beckleymeade Avenue
Dallas, Texas 75237

Dear Dr. Schwitters,

Professor Jerry Friedman has suggested I write to you to describe briefly some of the discussions I have had over the past few months with members of the GEM collaboration concerning possible eastern European participation in the work of the SSC.

I understand from Larry Sulak (a former colleague at Brookhaven who brought me into these discussions) that you are already somewhat familiar with the potential in Albania. In that regard, I have been asked to transmit a personal invitation from Albania: On behalf of the physicists of the University of Tirana, Faculty of Natural Sciences, Department of Physics, and the Academy of Sciences, Republic of Albania, Institute of Nuclear Physics, you and members of your staff and the GEM collaboration are warmly invited to visit the University, the Institute, and other scientific and technical sites in Albania, including copper facilities. I know that a formal invitation is on its way to you from Professor Rexhep Mejdani, Dean of the Department of Physics, and Dr. Perparim Fuga, Director of the Institute of Nuclear Physics.

During my last visit to Tirana, I mentioned your laboratory to Dr. Sali Berisha, the new President of the Republic. He was quite familiar with the SSC and expressed great interest in linking Albanian scientists and engineers to such world-class collaboration. A scientist himself, he will give his personal support to your visit or that of your colleagues. My partners in ALBUSA International - Tirana, a private Albanian-American enterprise, will be happy to assist in arrangements for any visit. Dr. Reardon's office has indicated he would like to visit at the end of July; that would be a fine time.

123 Egypt Lane
East Hampton, New York 11937
Tel. 1-516-324-6153

19, Avenue Trembley
1209 Geneva, Switzerland
Tel. 41-22-733-0377
Fax 41-22-733-9861

EURUS TECHNOLOGIES, Inc.

1, chemin Trolliet
1209 Geneva, Switzerland
Tel. 41-22-733-9377
Fax 41-22-733-9301

27 May 1992

By Facsimile 30-682-51297

Professor James R. Wiseman
Hotel Kleopatra
Kastrosikia
Preveza, Greece

Dear Professor Wiseman,

Again, thank you for your prompt letter of 15 May, giving all information on the Nikropolis Project schedule and participants.

The immediate good news for all of us, as reported by our ALBUSA colleague in Tirana, Mr. Fatos Osmani, is that U.S. and European citizens no longer need visas to enter Albania. We will check to make sure that Ms. Bienkowska of Poland is covered by this change. However, Mr. Osmani is working with the Ministry to assure that the field school group are met by appropriate and helpful people from the museum and university. I have sent him all the background info you gave me in Boston. As soon as you know your exact travel plans (when will you arrive at the border and when would you like to leave), Mr. Osmani can make hotel and other arrangements for the group.

As to your visit to Tirana at the end of the project, may I suggest that you give me exact dates when your travel schedule would permit a day or two in the capital. Since members of the Superconducting Super Collider "GEM" detector group are planning to visit at the end of July also, led by Larry Sulak, perhaps we can coordinate. Flights leave Tirana via Zurich or Rome every day except Sunday, although the Friday flight makes an out of the way stop in Budapest.

I hope this finds you well into your challenging summer's work and that ALBUSA International can discover a little more of Albania through your eyes.

Please let me know if I can be helpful in any way.

Sincerely,

Lynn Adams

Faculty of Natural Sciences

Department of Physicis

Dean	-Prof.Dr Rexhep Mejdani	SSPh(France,CEN-Sacley)	
	- Dr.Kastriot Islami	APh (France)	postgraduate
	Dr.Vladimir Laska	SSPh(France)	postgraduate
	Dr.Rajmond Sharko	SSPh(France)	postgraduate
	Dr.Maranglen Spiro	BPh (France)	posgraduate
	Dr.Gjergj Leka	NPh (France)	postgaduate
	Doc.Fatos Kiosi	SSPh(France-treining)	
	Doc.Floran Vila	SSPh(France-training)	
	Doc.Ilia Prifti	SSPh(Italy-training)	
	Doc.Meri Treska	SSPH(Germany-trainig)	
	Doc.Halil Sykja	T.Ph(France,Italy-training)	
	Doc.Niko Thomo	SSPh	
	Doc.Lulzime Aliko	SSPh	
	Doc.Zenun Mulaj	SSPh	

Candidat of Sciences ;

Patrit Berzhani	SSPH(France-trainig)
Afardita Vevecka	SSPh(China,Italy-training)
Bejo Duka	TPh (Italy-training)
Maria Dede	BPh (France-training)
Engjell Hysenbegasi	BPh
Bardhyl Guda	SSPH(Italy-training)
Nikolla Nosi	SSPh
Antoneta Dede	NPh(France-training)
Dhurata Xhuglini	SSPh(France-training)

Lecturer;

Zef Gjonaj	N.Ph
Dragan Gjikondi	SSPh
Ilo Xhunga	SSPH

Assistant;

Ilir Mele	SSPh
Kristi Pance	SSPh
Ariana Fuga	TPh
Artan Borici	SSPh
Edlira Ciu	B.Ph
Erika Gabej	B.Ph
Emil Xhuvani	B.Ph
Mishel Panariti	SSPh
Margarita Ifti	SSPh

Agim Gashi SSPh
Oranc Ciftja SSPh
Mirela Kuqo SSPh etc

Institut of Nuclear Physics tel.355-4232596
(Academy of Sciences) Fax 355-42-32759

Director; Dr.Perparim Fuga NPh
Dr.Petrit Skendo N.Ph
Dr.Jovan Thereska N.Ph
Dr.Agim Minxhozi N.Ph
Dr.Dukagjin Rexha N.Ph
Doc.Mario Kedhi N.Ph
Doc.Jovan Zoto A.Ph

Candidat of Sciences;
Baftjar Nevruzaj N.Ph
Andon Dodbibaj N.Ph
Xhevdet Mytaberi N.Ph
Sabri Zaganjori N.Ph
Alqi Kasneci N.Ph
Betim Cico E.N.Ph
Luan Karcanaj E.N.Ph
Fatos Ylli E.N.Ph
Drago Zeneli N.Ph

Abbreviation

SSPh= Solid State Physics
APh = Atomic Physics
N.Ph= Nuclear Physics
B.Ph= Biophysics
TPh= Theoretical Physics
E.N.Ph= Electronics and NuclearPhysics

SOME DEVICES

Electronic Microscope (Faculty of Scienc)
X-Ray difractometer (Feulty of Scienc)
Atomic Absorber (Faculty of Scienc)
X-Fluorescence (Inst of Nuclear Physics)
Generator of Neutrons (Inst of Nuclear Physics)
Mossbauer Device (Inst of Nuclear Physics) etc

Prof.Dr.Rexhep Mejdani tel.355 -42-26372 off
355- 42-25187 home
355-42-28258 Fax.

E-MAIL: SYSTEM@DINF.UNITI.AL.

+355422732 PLIRSA INT. TIRANA 906 P03 MAY 14 '92 07:40

EURUS TECHNOLOGIES, Inc.

1, chemin Trollet
1203 Geneva, Switzerland
Tel. 41-22-733-9377
Fax 41-22-733-9301

27 May 1992

By Facsimile

Professor L.R. Sulak
Physics Department
Boston University

Dear Larry,

MINSK

Attached are copies of recent correspondence with your department (please give to David as appropriate), just for your info. By the way, Ian Ross (still President Emeritus of Bell Labs) has agreed to look at AGAT with Eurus; BTL has "bought" about 100 fiber optics specialists in Russia so has gotten used to the idea (see enclosed article).

ALBANIA

Dates you and Paul Reardon suggest for Trana (25/26 July) are fine. I'll talk to Paul as soon as he's back from China via Moscow. Meanwhile, as of yesterday, Chris Hill of the Embassy says they are still expecting Berisha to go to U.S. in June but won't have final dates until end of this week.

Ciao!

Lyn

UNIVERSIDAD SAN FRANCISCO DE QUITO

CANCILLERIA

ECUADOR...

Joint Letter of Intent

As a part of becoming a full contributing member of the GEM Collaboration at the U.S. Superconducting Super Collider Laboratory (SSC), the Institute of Applied Sciences (IAS), a unit of the Coporación de Promoción Universitaria – University San Francisco of Quito (USFQ), intends to pursue the following mutually beneficial projects with the GEM Collaboration and the SSC:

1) Develop a plan to contribute to the construction of the GEM Detector at the SSC. At this time, we anticipate assembling, testing and installating (into the copper absorber) the optical package consisting of scintillating fibers, light mixer, photo multipliers and bases of a fiber calorimeter, should it become the hadronic subsystem of choice for the GEM Detector. We understand that the components would be delivered to us and transhipped to the SSC. In the event that another technology is chosen, our contribution to GEM would not be constrained by this initial project, nor will our contribution be limited to it. We anticipate signing an interlaboratory agreement and protocol with the SSC Lab at the earliest possible date to confirm this intent.

2) As a source of potential funding for the facilities improvement, test equipment, technicial manpower and training necessary for the project described above, both IAS and GEM (in cooperation with the SSC Lab) will endeavor to obtain an exchange of US/Ecuadorian debt for this development. The USFQ will negotiate with the Ecuadorian Government for up to $10M of debt exchange. GEM intends to pursue obtaining the appropriate agreement in the US to obtain this amount of contribution from IAS for the GEM Detector.

May 29, 1992
Boston, Massachusetts

Santiago Gangotena G., PhD
Chancellor
Universidad San Francisco de Quito
Ecuador

L. Sulak
for the International Committee
GEM Collaboration
Boston University

TOTAL P.02

Minsk

EURUS TECHNOLOGIES, Inc.

1, chemin Trolliet
1209 Geneva, Switzerland
Tel. 41-22-733-9377
Fax 41-22-733-9301

27 May 1992

Professor George Zimmerman
Supersolder Technologies, Inc.
590 Commonwealth Avenue
Boston, MA 02215

Dear George,

Another challenging week in Belarus! As usual, hospitality was remarkable and all your friends, especially Academician Roman, send you greetings.

"USSR" Academician

After good discussion with Oleg and Bill Begell (Byelocorp's science specialist), we have reached the following agreements on our side:

New Director of NSF

- Oleg Roman will lead a team to provide you with twenty samples of your rod design, twenty samples of PMI's tubular design, and some number of each design on a bismuth base.

- Oleg will deliver the samples to you in person when he comes to the U.S. for a Powder Metallurgy conference at the end of June.

- Oleg prefers that you do the contacts in Boston for the samples. He will of course do them if you insist, but says it is too difficult to work this out for just the limited number of samples.

- Byelocorp will act as the contracting party with Community Technologies Foundation / Suprsolder Technologies, Inc.

- Byelocorp proposes a price of $40,000 USD (forty thousand US dollars) to provide you with what we have been calling "phase I" material, including all the extra tubular and bismuth samples, as well as the early delivery.

+ invitation to
GEM Collaboration Meeting
July 2

Belarus

In the Republic of Belarus, scientists at the Powder Metallurgy Institute are making test samples of superconducting ceramic material for a U.S. laboratory. Academician Oleg. V. Roman, Chairman of the newly formed National Science Foundation of the Republic (and an Academician of the former USSR Academy of Sciences), will be in the U.S. in late June for a scientific conference and collaboration meetings, some concerning the superconducting ceramic work. His possible visit to the SSC is under discussion within the GEM collaboration.

I would greatly appreciate the opportunity to meet you and answer any questions you may have about any of these activities. I will be in the U.S. soon and would be able to see you in Texas July 1 or July 2, if you have time on either of those dates. I enclose some background material on my overall work.

SSC GEM Collaboration Council

It is a privilege to bring some of these talented people to your attention. Their troubled history does not prevent them from aspiring to a productive future. I look forward to meeting you soon in Texas to explore their potential contribution to the SSC.

Sincerely,

Lyn Adams

Lyn Adams
President
Eurus Technologies, Inc.

Enclosure
cc: J. Friedman, L. Sulak

Test of Minsk Ability/Credibility

EURUS TECHNOLOGIES, Inc.

1, chemin Trolliet
1289 Geneva, Switzerland
Tel. 41-22-733-9377
Fax 41-22-733-9301

25 May 1992

Mr. Eric Hazen
Mr. Dmitry Orloff
Electronics Design Facility
Physics Department
Boston University

GEM CALORIMETER ELECTRONICS ENGINEERING

Dear Eric and Dmitry,

I presented your proposal to the Director and staff of "AGAT" Institute in Minsk last week. After discussion and a detailed tour of their facilities the next day, they offered me the enclosed letter of intent. They also gave me several examples of their PCB and copper strip technology which I have here in Geneva and will get to you as soon as possible. Their previous mission assures me that these are among the very best people the CIS has to offer in their field. I would be happy to give you more information on their previous work and their current situation when we next speak.

To answer a few of your specific questions:

1. They do multilayer boards. I have samples of their 8 layer boards.

2. They can make oversized boards as large as 400 x 400 cm (!)

3. They have "IBM 360/370 type" computers and "IBM XT/AT type" PCs. That means machines they have built themselves. I saw these in operation, running DOS etc. Naturally they would like to upgrade their equipment as this becomes necessary and possible.

4. Byelocorp's attorney is checking the latest export control lists for us.

5. Average wage for scientist/engineer is now up to 5000 rubles per month (less than $50).

Let's talk at your earliest convenience since AGAT is a remarkably talented gang and could definitely add high quality, very low cost additional muscle to your group.

Sincerely,

Lyn Adams

Enclosure

SCIENTIFIC-RESEARCH
INSTITUTE «AGAT»

THE REPUBLIC OF BYELORUSSIA
220067 Minsk
Zhodinskaya str., 21
tel. 63-76-84
64-64-22
telex: "Verba"
telefax: 63-56-20

INSTITUTE CHARACTERISTIC:

The scientific-research institute "Agat" is a modern enterprise involved in development and production activities. The institute is possessed of rich experiences of designing and installing application-specific automated information and management systems and has at its disposal the necessary technological and production basis with the staff of about 1000 competent employees. There are complex-modeling center, well-developed design, technological, production, information, meteorological, supply and other auxiliary services in our institute as well as a hotel with a restaurant and a conference hall with a seating capacity of 500.

The scientific-research institute "Agat" specializes in systems and their software and hardware components engineering for communication, judicial, aircraft control, public health, fire control departments, etc..

OUR OFFERS:

The institute is interested in receiving orders for design, delivery, installation and further maintenance of automated information and management systems of any kind including real-time systems;

- receiving orders for software engineering for use on all computers including PC IBM-360/370, IBM PC XT/AT and other. The software engineering can de carried out in any of the most common programming languages: Assembler, PASCAL, C;

- setting up production and sale of radioelectronic devices, small-scale production of unique products with a large amount of hand labour on the basis of its own;

- providing hotel apartements, halls for conducting conferences as well as document copying, communication, transportation and public servicing.

Minsk

AGAT Scientific Research Institute
Zhodinskaya 2I, 220067 Minsk, Republic of Byelorussia
Tel.:0I72/646422 Fax:0I72/635620 Telex:Verba 252271

1.) PLASTIC & QUARTZ FIBERS + also pursuing Moscow Source for fibers
2.) Electronics

Minsk
2Ith May,I992

Dear Mrs.Adams,

The AGAT Scientific Research Institute (Minsk) which is under the jurisdiction of the Republic of Byelorussia asks You to render assistance in establishing business contacts with foreign scientific research or production organizations and firms.

The institute is interested in receiving orders for software tools development on the base of a computer of any type including IBM 360/370 and IBM PC XT/AT. By the software development can be used one of the most widely spread programming languages such as Assembler, Pascal and C.

The AGAT Institute is ready to take part in developing, spreading and installing software products of foreign firms in the Rapublic of Byelorussia as well as in development, delivery and installation of any information management systems including real-time ones.

The institute has at its disposal the necessary technological and production base with the staff of highly skilled specialists.

Yours faithfully,

Sysoyev
Institute Director

+ all advanced electronics for "USSR" Space Agency

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- Silver Plated Bus Bar

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- Leaded

machines best = Te

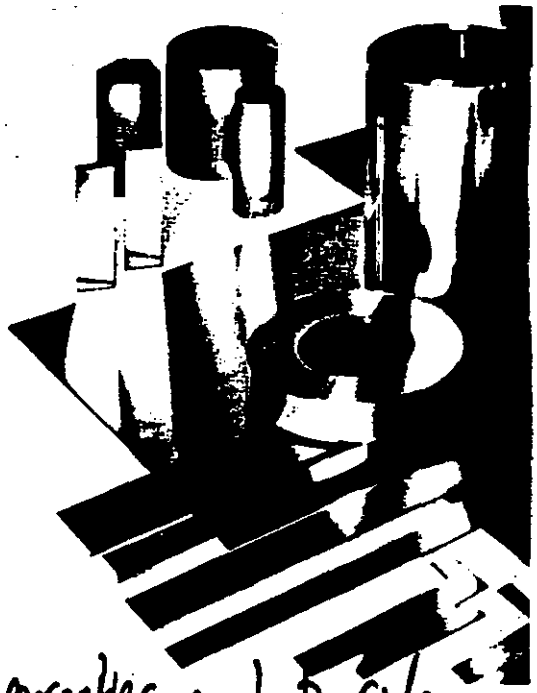
OFHC Copper Rod

Copper Radiator Strip

Copper Tube and Pipe

Cu $1.60 → Te Cu $1.65

cost/lb



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Long term optimization:

See back page for branch locations.

next: 1) use extruded copper with grooves on both sides
2) eliminate tubes

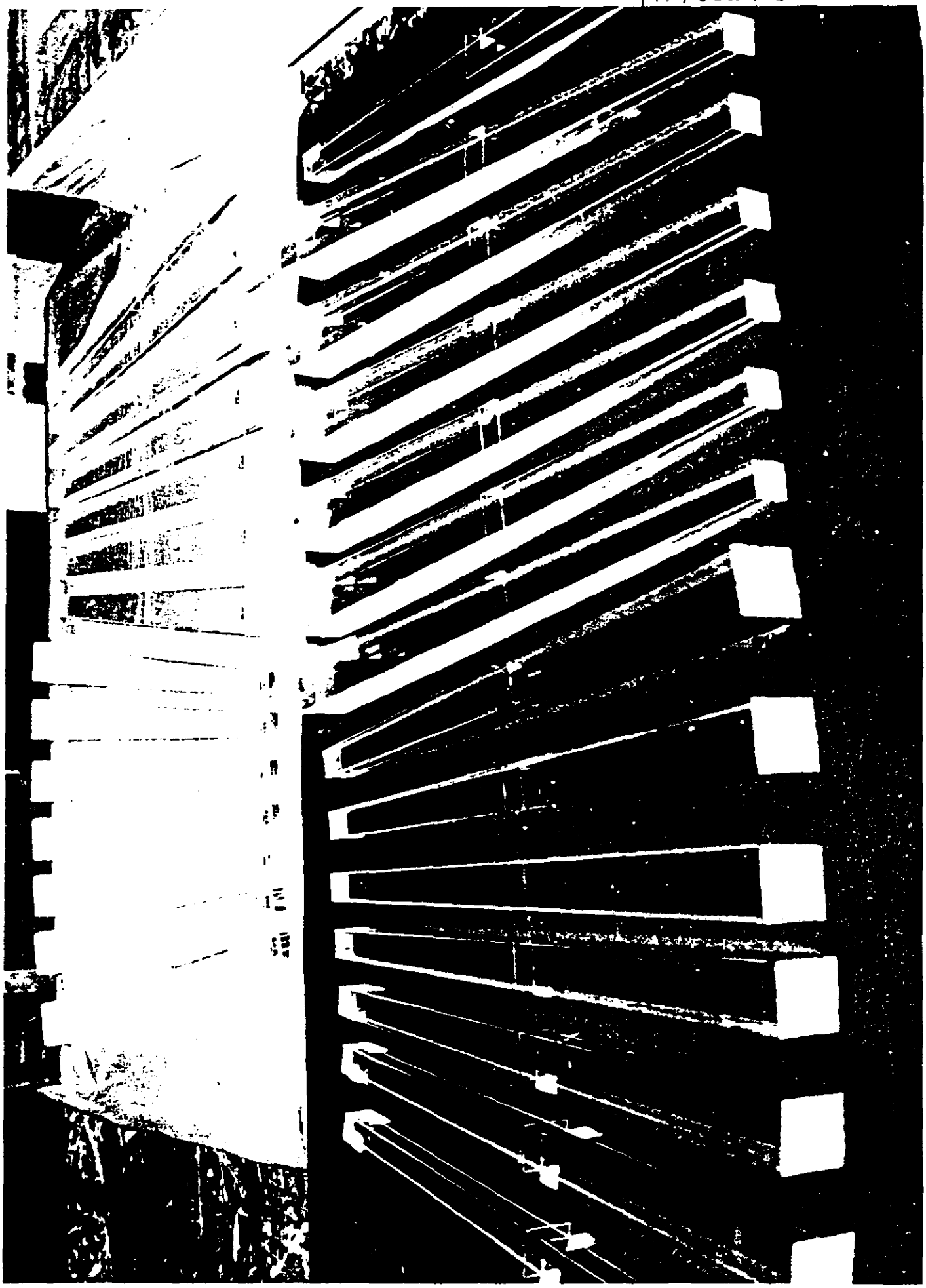
gem

γeμ

Presentation by:

H. Newman

H. NEWMAN



BaF_2 R&D May 1992:

RADIATION DAMAGE STUDIES; MATERIALS STUDY, MANUFACTURE

- NEUTRON IRRADIATION AT UNIV. LOWELL
- SIC: OXYGEN, FAST COOLING, and DAMAGE
- TONGJI UNIV: DAMAGE MECHANISM STUDY: HYDROLIZED BaF_2
- MICROANALYSIS At CE&A
- LLNL – SMALL ULTRA-PURE CRYSTAL GROWTH
- LLNL: SURFACE LAPPING, POLISHING, COATING. MECHANICAL PROCESS DESIGN
- PLANS: HADRON IRRADIATIONS AT THE AGS, and LAMPF (800 MeV) IN JUNE

Radiation Laboratory, University of Mass. Lowell
Irradiation Report for Brookhaven National Laboratory
April 29, 1992

1. Summary

Two barium fluoride scintillators were irradiated with fast neutrons on April 29, 1992 at the University of Massachusetts Lowell Van-de-Graaff Accelerator, in one eight-hour exposure. Neutron and gamma fluences and gamma dose estimates at five locations are shown in Table 1.

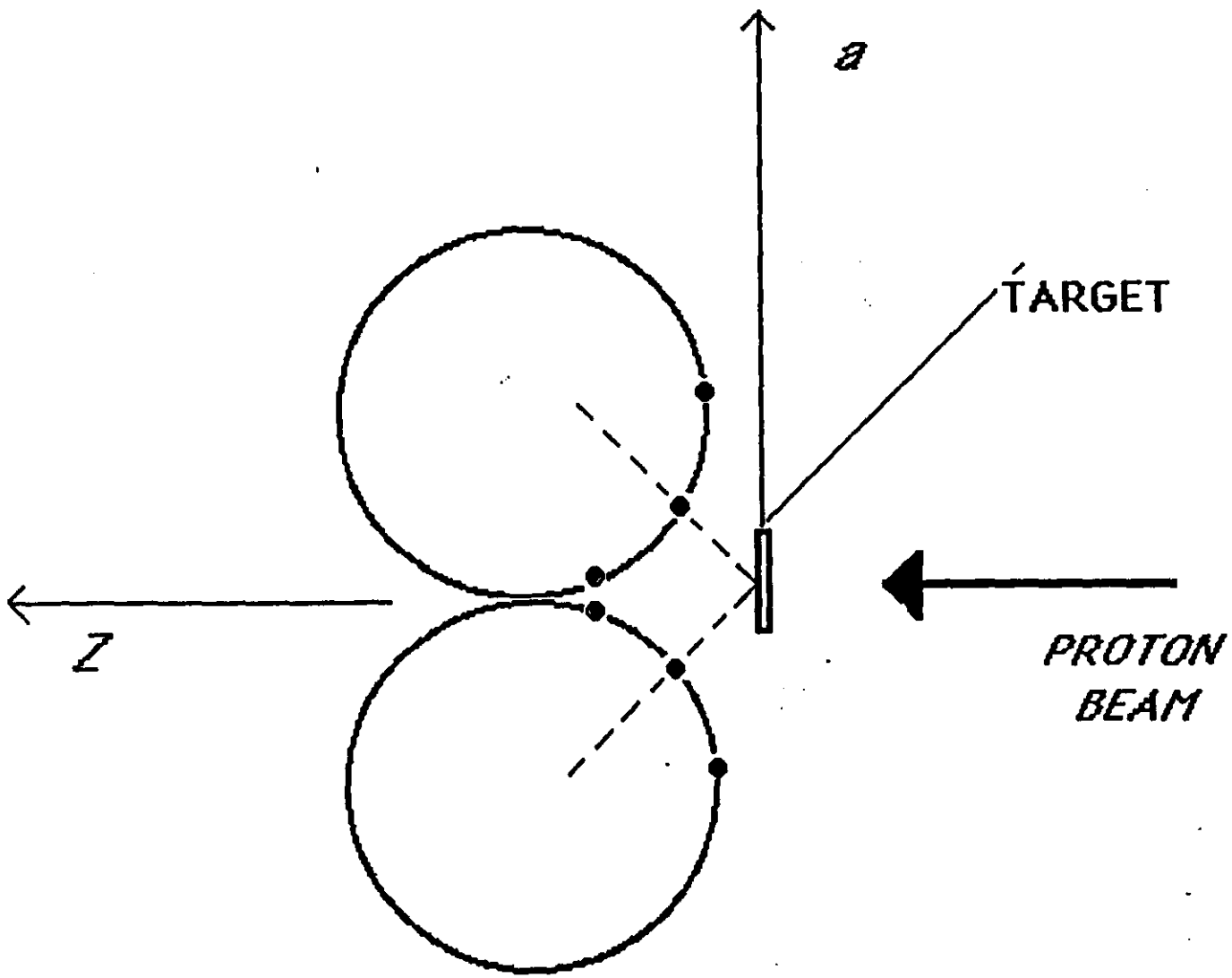
• Fast neutrons: $5\text{-}8 \times 10^{13}$ n/cm^3

Table 1. Neutron and Gamma Fluences

• Low γ-Flux

Location	Axial Distance, z [cm]	Radial Distance, a [cm]	Fast Neutron Fluence [n/cm^2]	Gamma Fluence (429.2keV) [γ/cm^2]	Estimated Gamma Upper Limit [rad]	Surface Dose Lower Limit [rad]
1	1.019	1.785	7.30×10^{13}	4.56×10^{12}	1970	924
2	0.318	2.269	6.52×10^{13}	3.67×10^{12}	1580	740
3	0.797	1.785	8.27×10^{13}	5.04×10^{12}	2180	1022
4	1.477	1.751	5.44×10^{13}	3.67×10^{12}	1580	741
5	1.019	1.785	7.30×10^{13}	4.56×10^{12}	1970	923

→ CONCLUSION: Little Affect, Apart from 1-2 KRad γ's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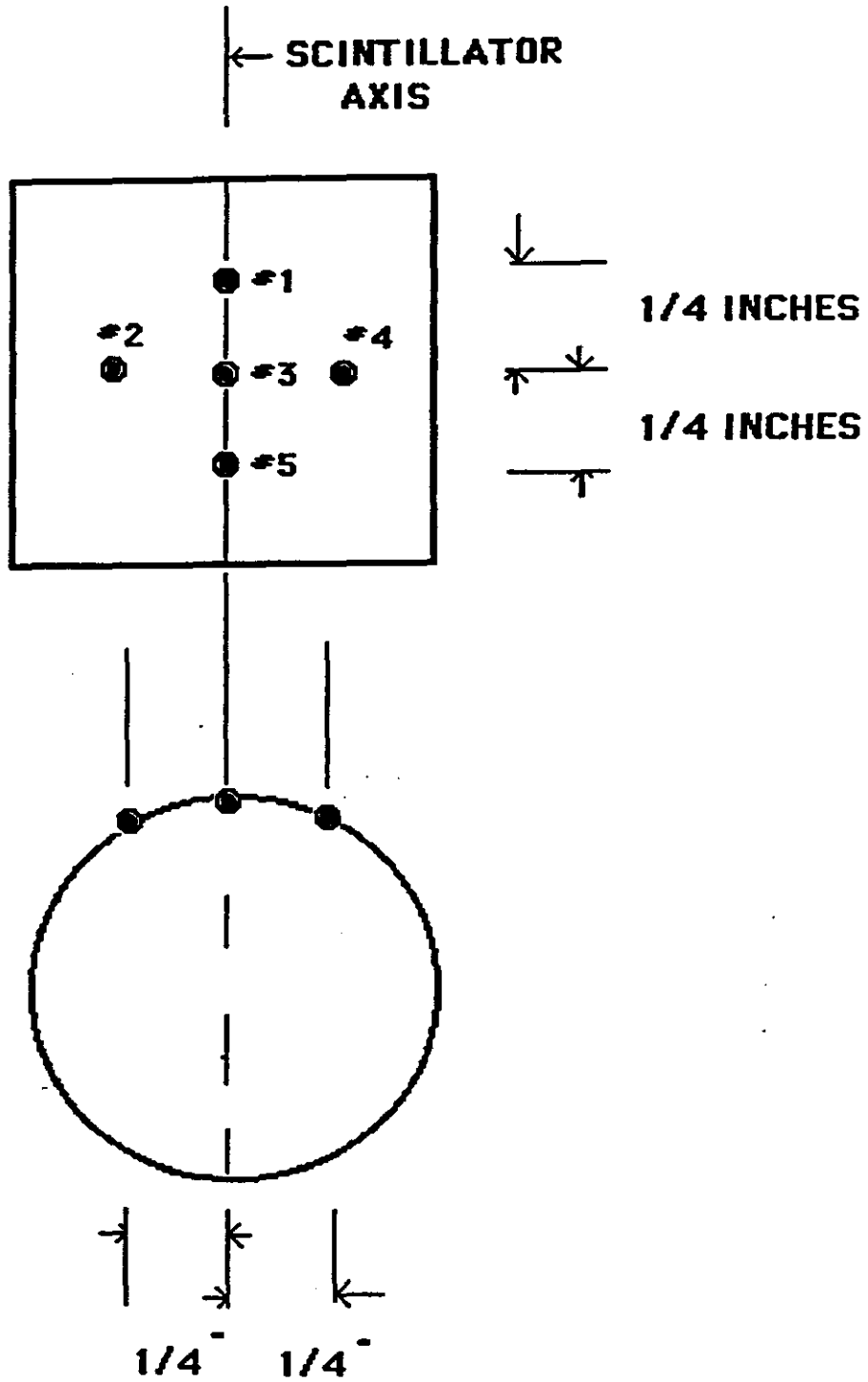
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#2
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#4
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1/4 INCHES
1/4"
1/4"

NEUTRON ENERGY SPECTRUM.
University of Lowell. 3:48 AM TUE., 12 MAY , 1992

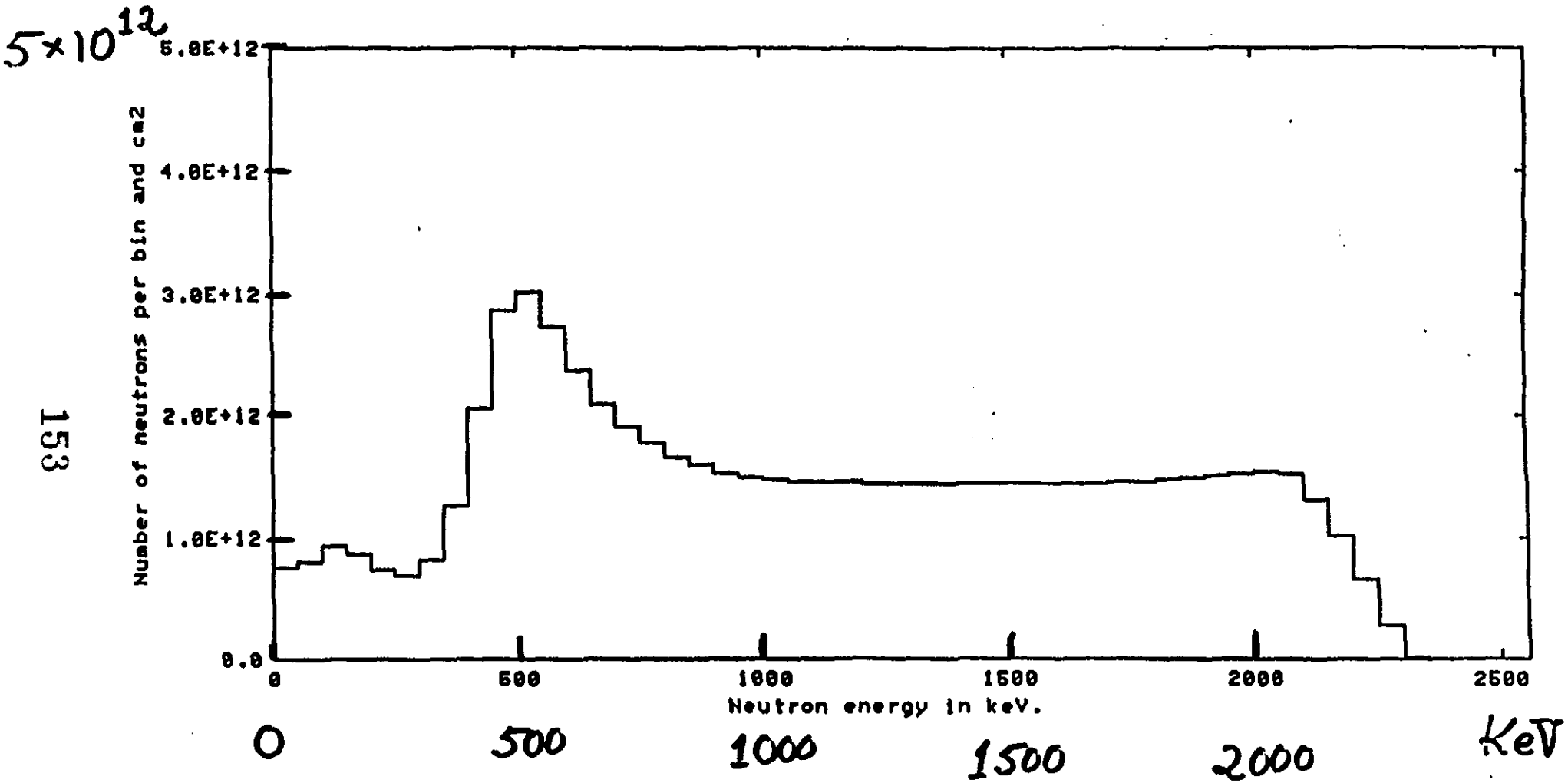
The following table gives the neutron fluence in neutrons per cm2, for an irraddiation of a thick lithium target with a 4000 keV proton beam.
The total charge delivered to the target is
578.2 mC.

"MURI" SIMULATION CODE

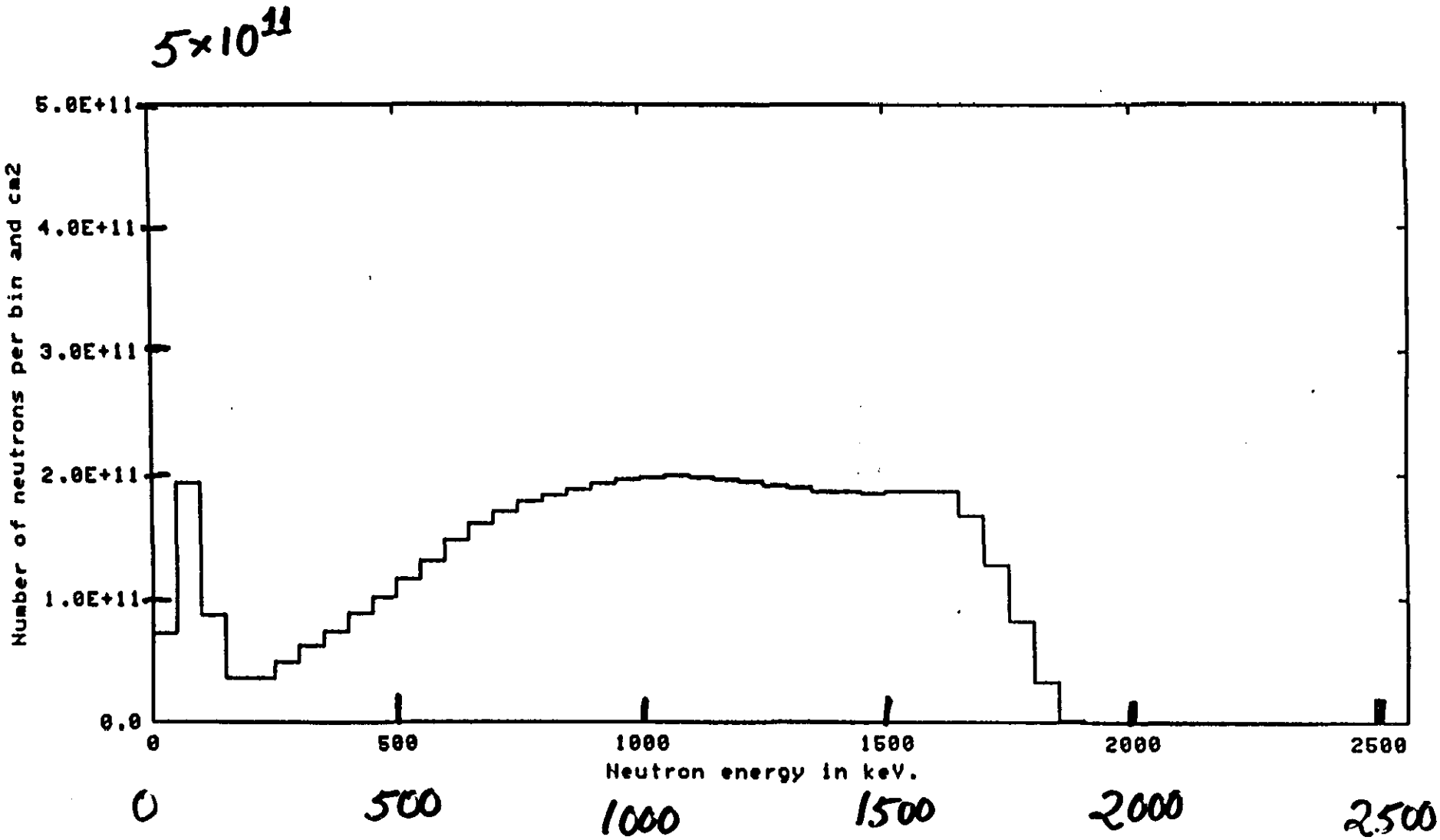
The parameters are:
a= 1.019 cm.
z= 1.785 cm.
R= .8000 cm.
Kappa= 20.00
Slow neutrons (En < 10 keV) per cm2: .5222E+11
Fast neutrons (En > 10 keV) per cm2: .6758E+14
Equivalent number of 1MeV-neutrons per cm2: .6488E+14
The total number (angle and energy integrated) of neutrons generated is: .1694E+16
The output file name is BARF31

Bin number	Bin energy [keV]	Number of neutrons per cm2	ASTM KERMA (E722-85) divided by 95.0MeVmb	1Mev equivalent number of neutrons per cm2
1	30	.749E+12	.233E-01	.175E+11
2	75	.812E+12	.626E-01	.508E+11
3	125	.940E+12	.425E-01	.400E+11
4	175	.871E+12	.425	.370E+12
5	225	.744E+12	.824	.613E+12
6	275	.689E+12	.587	.404E+12
7	325	.823E+12	.548	.451E+12
8	375	.126E+13	.546	.688E+12
9	425	.206E+13	.565	.116E+13
10	475	.286E+13	.594	.170E+13
11	525	.302E+13	.966	.291E+13

• UNIV. of LOWELL
Computed neutron Spectrum - I



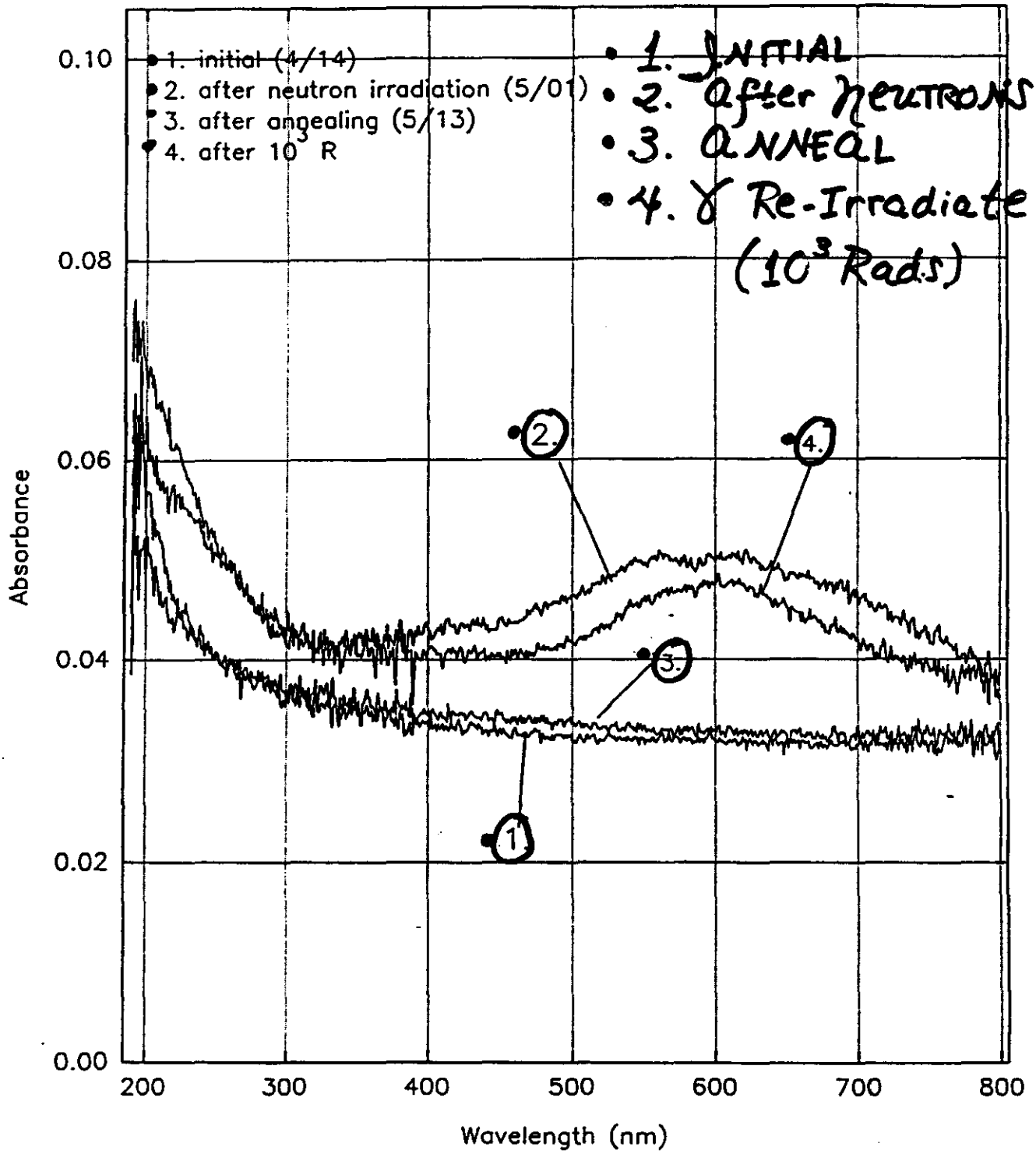
• UNIVERSITY of LOWELL
COMPUTED NEUTRON SPECTRUM-II



SIC

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

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

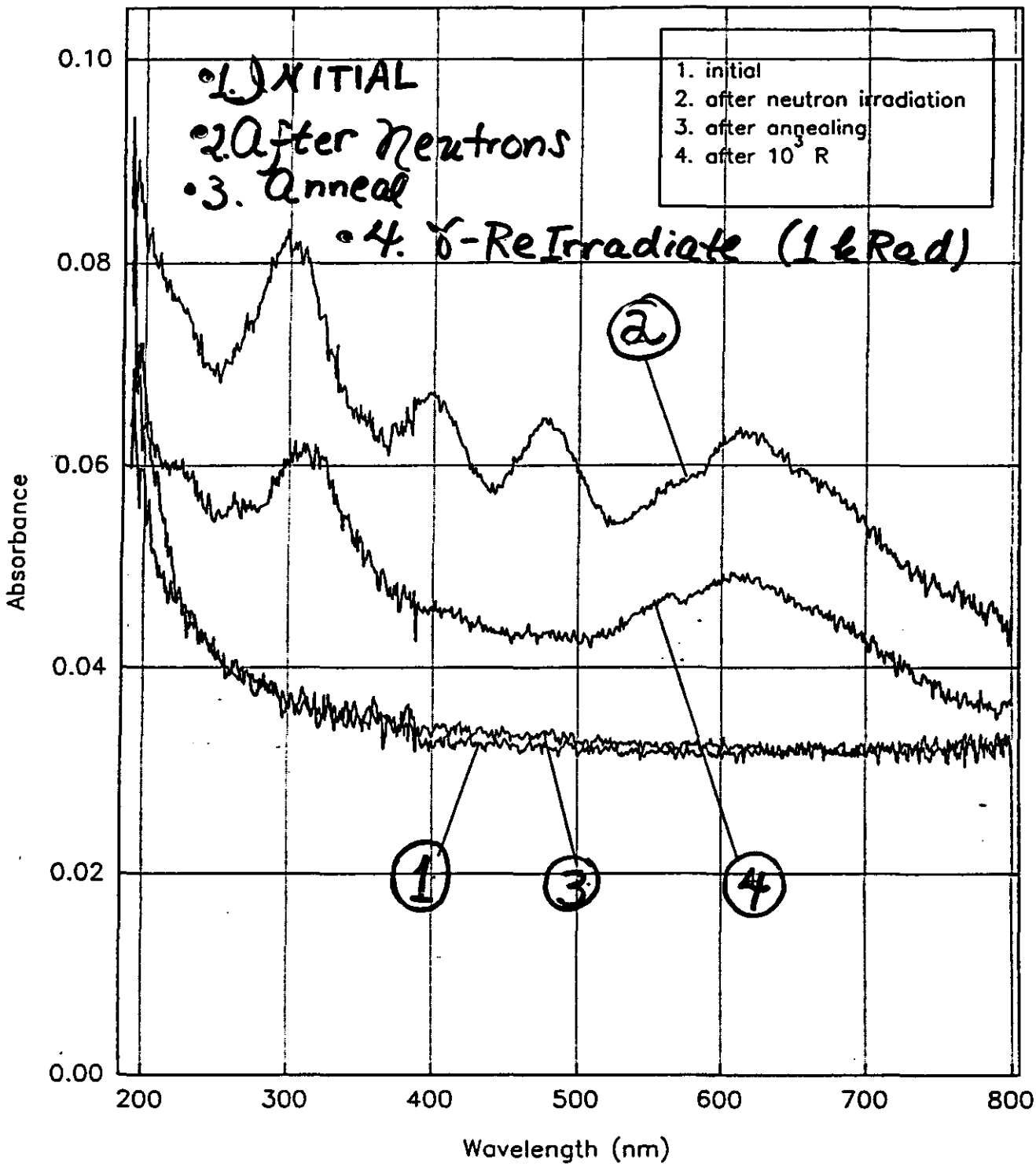


• C. WOODY et al. (BNL)

KORTH

BaF_2 1" X 1" cylinder #k14430b 5/26/92

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



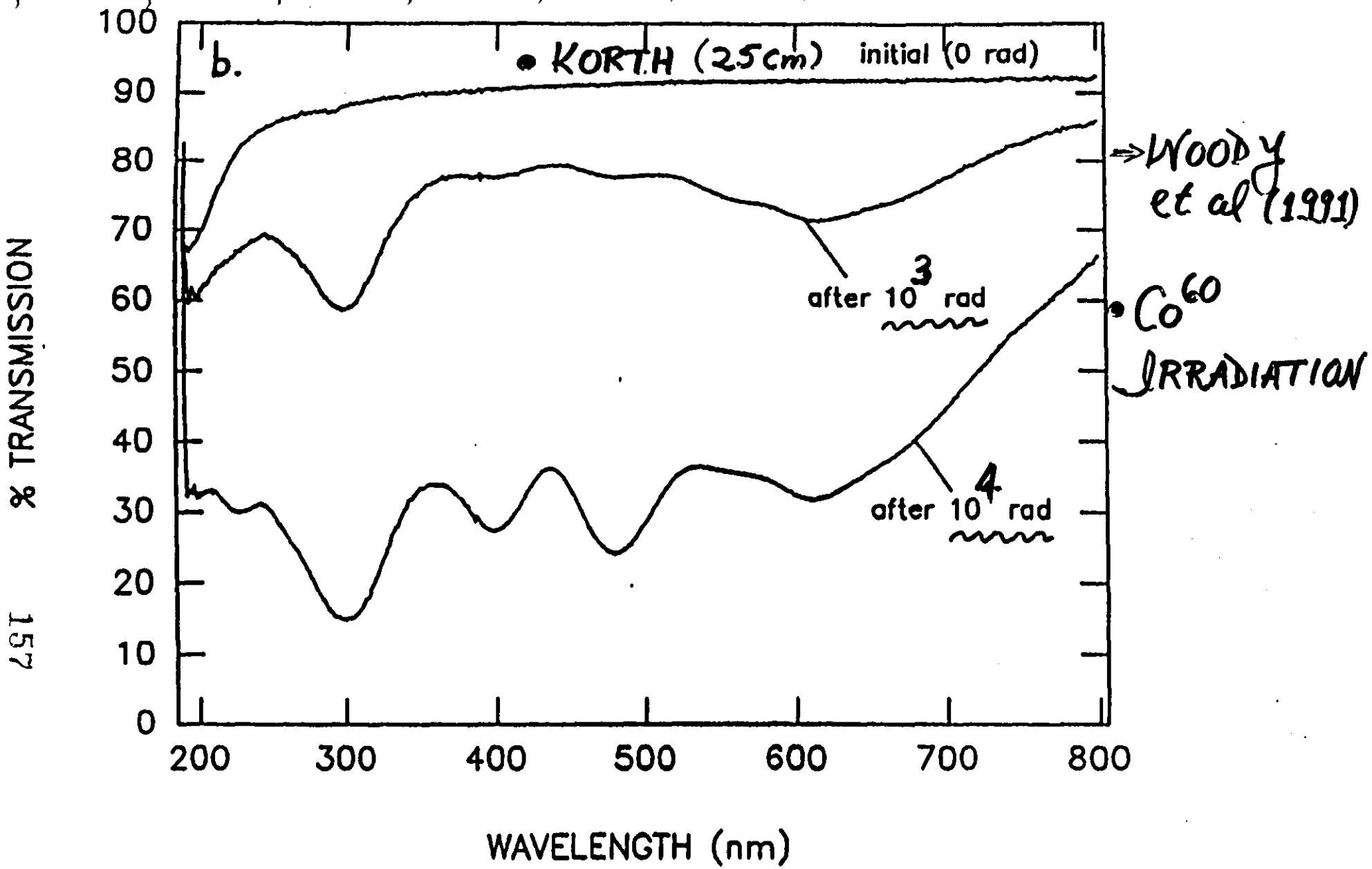


Fig. 5: Transmission spectra of 25 cm BaF_2 trapezoids measured after 10^3 and 10^4 rad, (a) SIC sample (b) Korth sample.

NEUTRON ENERGY SPECTRUM.
University of Lowell. 3:48 AM TUE., 12 MAY , 1992

The following table gives the neutron fluence in neutrons per cm2, for an irraddiation of a thick lithium target with a 4000 keV proton beam.
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11	525	.302E+13	.966	.291E+13
12	575	.272E+13	1.14	.312E+13
13	625	.236E+13	.600	.142E+13
14	675	.209E+13	.612	.128E+13
15	725	.190E+13	.669	.127E+13
16	775	.177E+13	.886	.157E+13
17	825	.166E+13	1.02	.169E+13
18	875	.159E+13	.899	.143E+13
19	925	.153E+13	1.03	.158E+13
20	975	.150E+13	.967	.145E+13
21	1025	.148E+13	.763	.113E+13
22	1075	.147E+13	.659	.969E+12
23	1125	.146E+13	.659	.963E+12
24	1175	.146E+13	.463	.674E+12
25	1225	.145E+13	.463	.672E+12
26	1275	.145E+13	.736	.107E+13
27	1325	.145E+13	.736	.106E+13
28	1375	.144E+13	.975	.141E+13
29	1425	.144E+13	.975	.141E+13
30	1475	.144E+13	1.04	.150E+13
31	1525	.144E+13	1.04	.150E+13
32	1575	.145E+13	1.07	.155E+13
33	1625	.145E+13	1.07	.155E+13
34	1675	.145E+13	1.27	.184E+13
35	1725	.146E+13	1.27	.185E+13
36	1775	.147E+13	1.02	.149E+13
37	1825	.148E+13	1.02	.151E+13

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

Optical Crystals

To Harvey Newman

From Rob Sparrow

4/28/92

BARIUM FLUORIDE : STATUS REPORT

• "SMALL" PURE CRYSTAL PROGRAM

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

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

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

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

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

BaF2 Crystal Growing

- Small (cm) samples of ultra-pure BaF2 will be grown using zone refining in reactive gas atmosphere and inert gas atmosphere.
- Dr. W. Kway maintains a number of zone-refining and Tzochowski process crystal growing systems. Experienced with growing fluorides of all kinds.
- Ultra-dry/pure BaF2 powders ordered from Fluortran and Johnson-Massey.

Schedule:

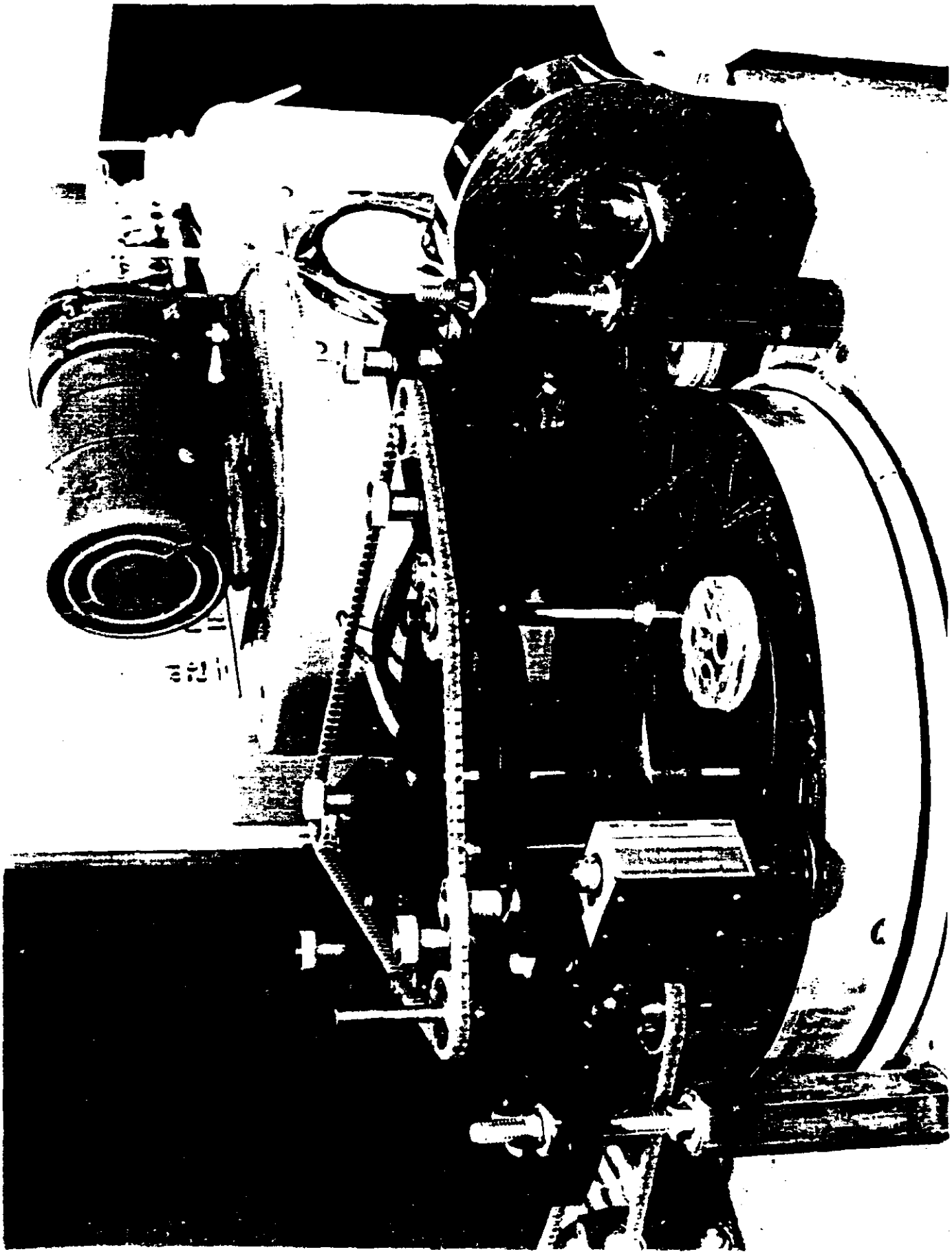
- Week 1 (June1): initial pre-treat of BaF2 in HF atmosphere at high temp.
- Week 2: zone refine first sample and evaluate for impurity and quality.
- Weeks 3-8: Parallel effort to grow BaF2 using different sources and different growth methods - all crystals to be chemically analyzed at LLNL and Charles Evans and Associates.
- As crystals are made available, B. Fuchs will polish and samples will be analyzed for optical properties and radiation hardness.

BaF2 UV Reflective Coatings

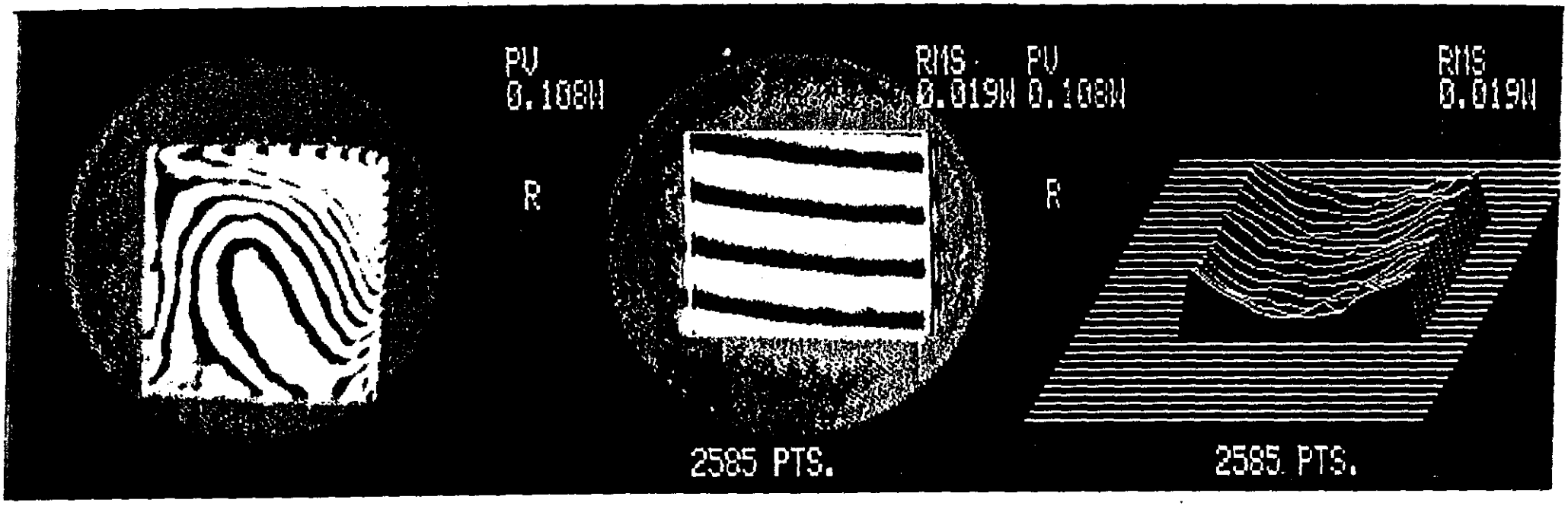
- Aluminum/MgF2 coatings applied and analyzed at LLNL - 90% @ 220 nm.
- Scatterometry and Reflectometry measurements on new samples in progress.
- Cost estimates have been made for coating 15,000 crystals: $1M - $1.5M (TECHNOLOGY TRANSFER)
- LLNL owns and operates a number of large (3m x 3m x 3m) evaporative coaters at Spectra-Physics and Optical Coatings Laboratory, Inc. (OCLI).
- Discussions will be held with BGRI to transfer coatings technology (coating composition, masks for graded coatings) to their large evaporative coating system.
- Discussions with coatings experts at LLNLto evaluate long term integrity of coatings - accelerated aging tests, etc.
- Summer student at LLNL to evaluate 50 cm BaF2 for linearity with various coatings using HTV R-431S PMT (CsTe photocathode) and Co-60, SR-90 sources.

BaF2 Surface Preparation and Analysis

- Diamond Pitch Wheel Polishing method chosen for surface preparation.
- Interactions with J. Heck - ORNL to develop the necessary polishing procedures to satisfy mechanical specifications.
- Design and fabrication of polishing blocks and fixtures is proceeding at LLNL.
- Trips to Shanghai and Beijing planned - early June, mid-summer.
  - → B. Fuchs and C. Wuest to meet with SIC, BGRI, Wuhan Defense.
  - → Evaluate Chinese technology and equipment.
  - → Suggest LLNL-developed polishing methods and begin discussions on adapting existing polishing machines to new methods.
- Visits to LLNL by Michel Lebeau and others during the summer.



BaF2 Surface Preparation and Polishing



Chinese-finish on 4 cm x 4 cm crystal end face

LLNL-finish on 4 cm x 3 cm cut BaF2 sample

Surface scan of LLNL-finished sample: 0.108 λ P-V @ 633 nm

CHARLES EVANS & ASSOCIATES

SPECIALISTS IN MATERIALS CHARACTERIZATION

May 13, 1992

TO: Harvey Newman
Lauritsen Laboratory
California Institute of Technology
391 S. Holliston
Pasadena, CA 91125

FM: Michael D. Strathman

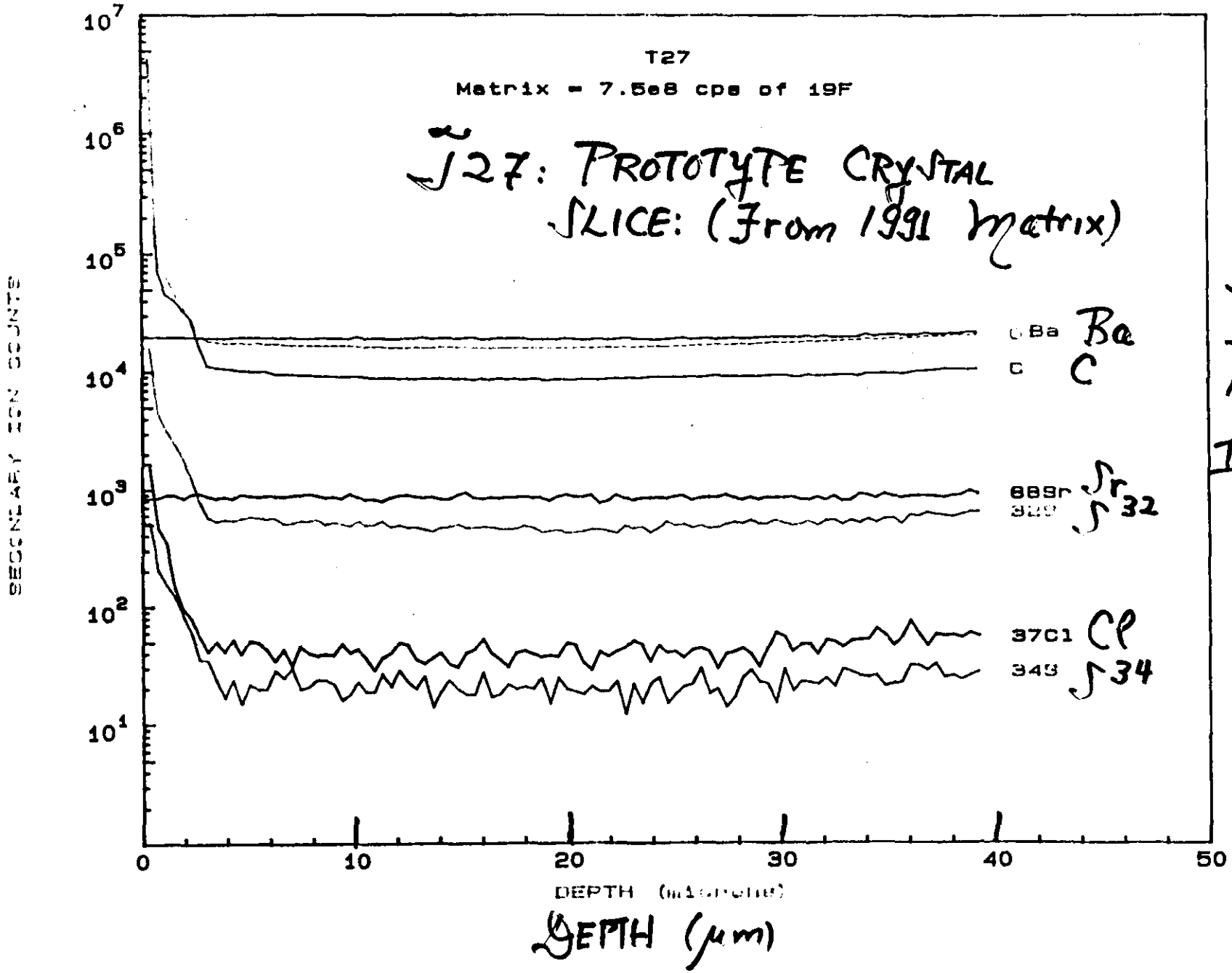
RE: SIMS Report for work performed April 1 and 9, 1992.

Previously reported results:
The results of the oxygen bulk measurements and the deep depth profiles have been faxed or attached to previous reports. Confirming copies of this data are included in this report. The oxygen data is presented in table #1. The deep depth profiles are presented in figures #0 through #4. Figures #0 and 1 are color plots of profiles in which inclusions were not found. Figures #3, 4 and 5 show evidence of inclusions.

SIMS Elemental Imaging:
Three sequences of SIMS elemental images were acquired from sample T27 cut from the 1 of 19 prototype crystal. These data are presented in figures #5 through #14. All images were taken with a 150um x 150um image area at a depth of less than twenty microns from the surface of the cleave. Figure #5 is a background check of the RAE detector. This image shows the residual noise on the image detector when no signal is present.

PROCESSED DATA
9 Apr 92 Cs

CHARLES EVANS AND ASSOCIATES
FILE: 1



~ Fig. 0
no
INCLUSION

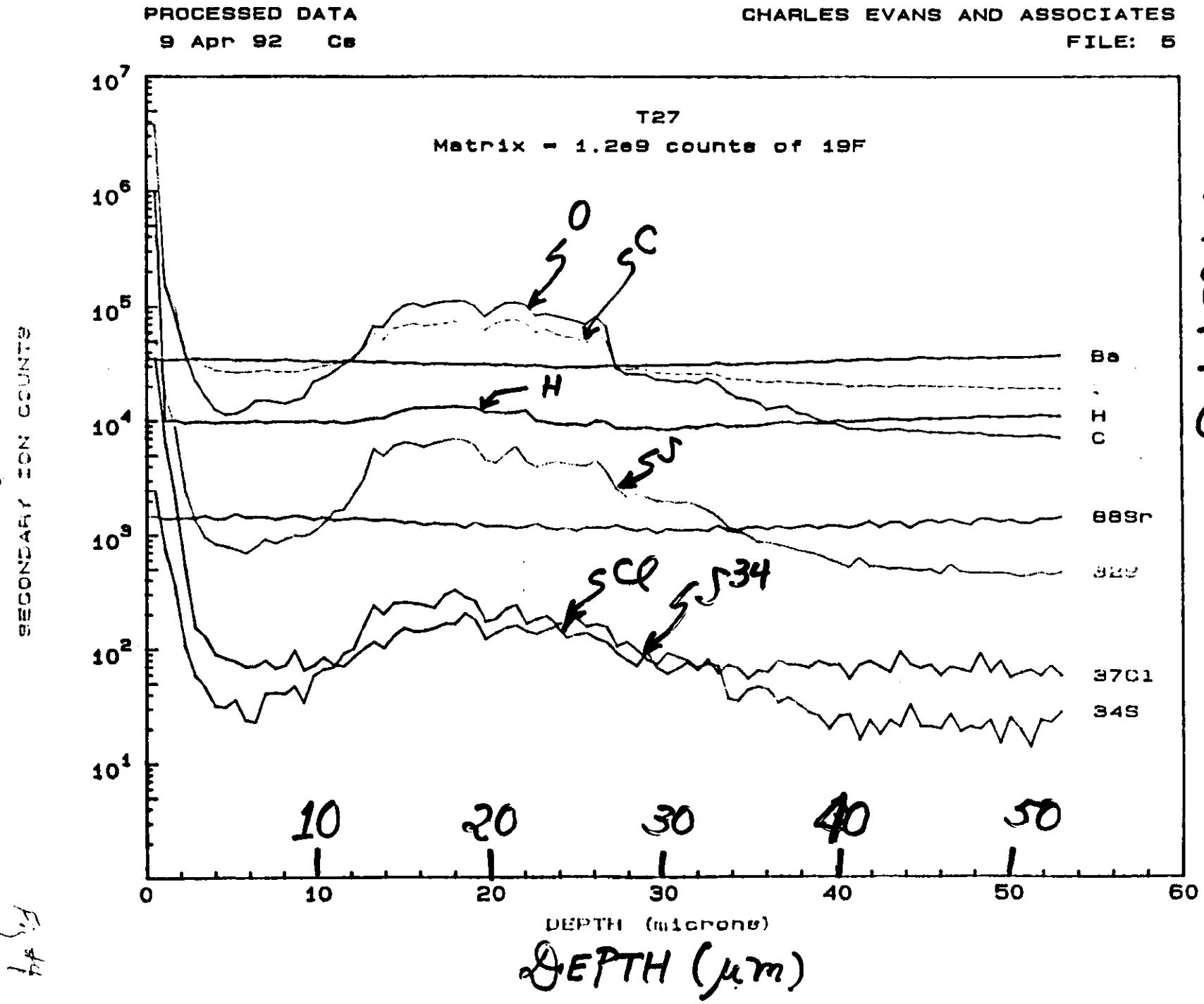
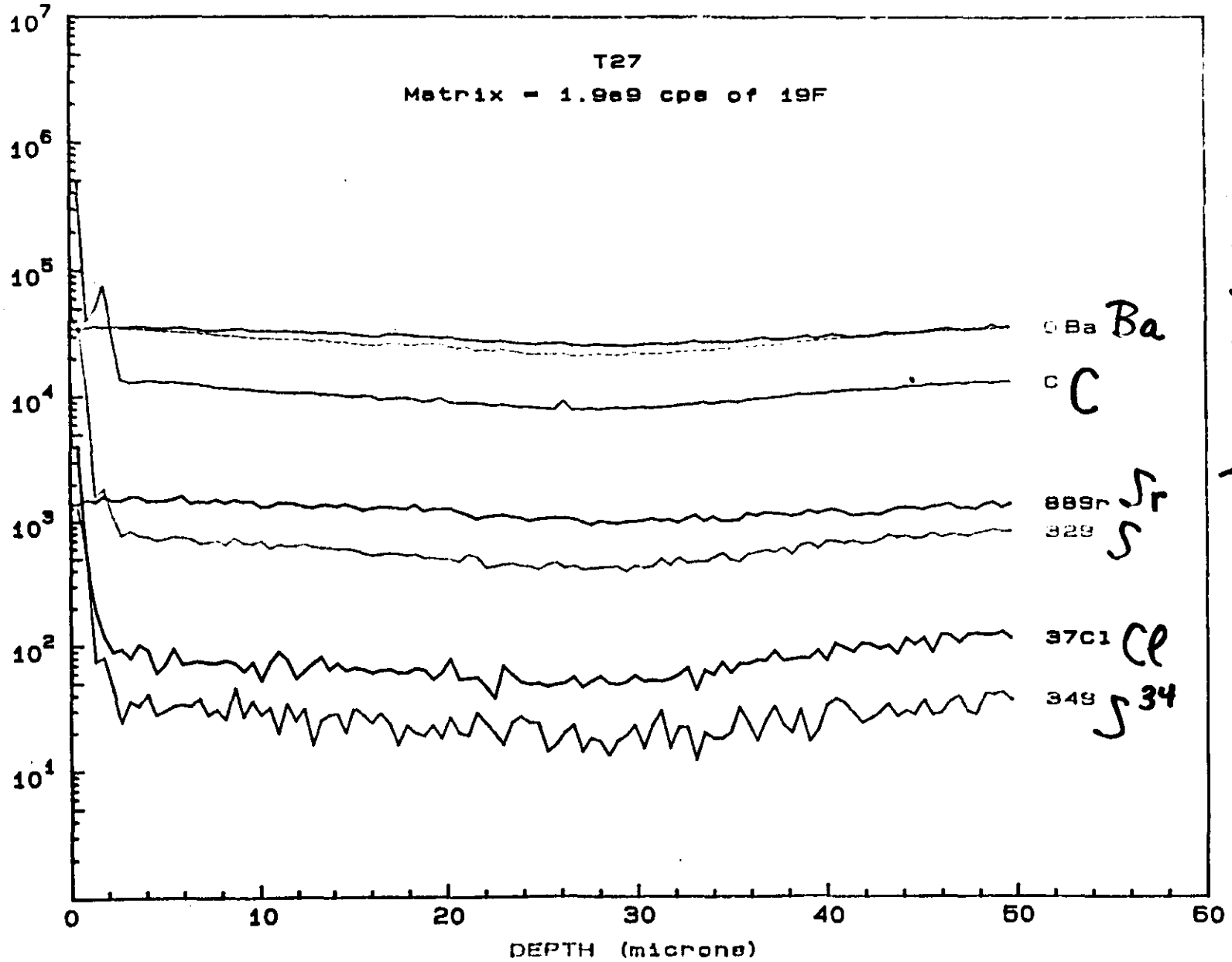


Fig. 4: One Inclusion O, C, H, S, Cl

PROCESSED DATA
9 Apr 92 Cs

CHARLES EVANS AND ASSOCIATES
FILE: 2



~ Fig 1
No Inclusion

Fig #1

PROCESSED DATA
9 Apr 92 Cs

CHARLES EVANS AND ASSOCIATES
FILE: 3

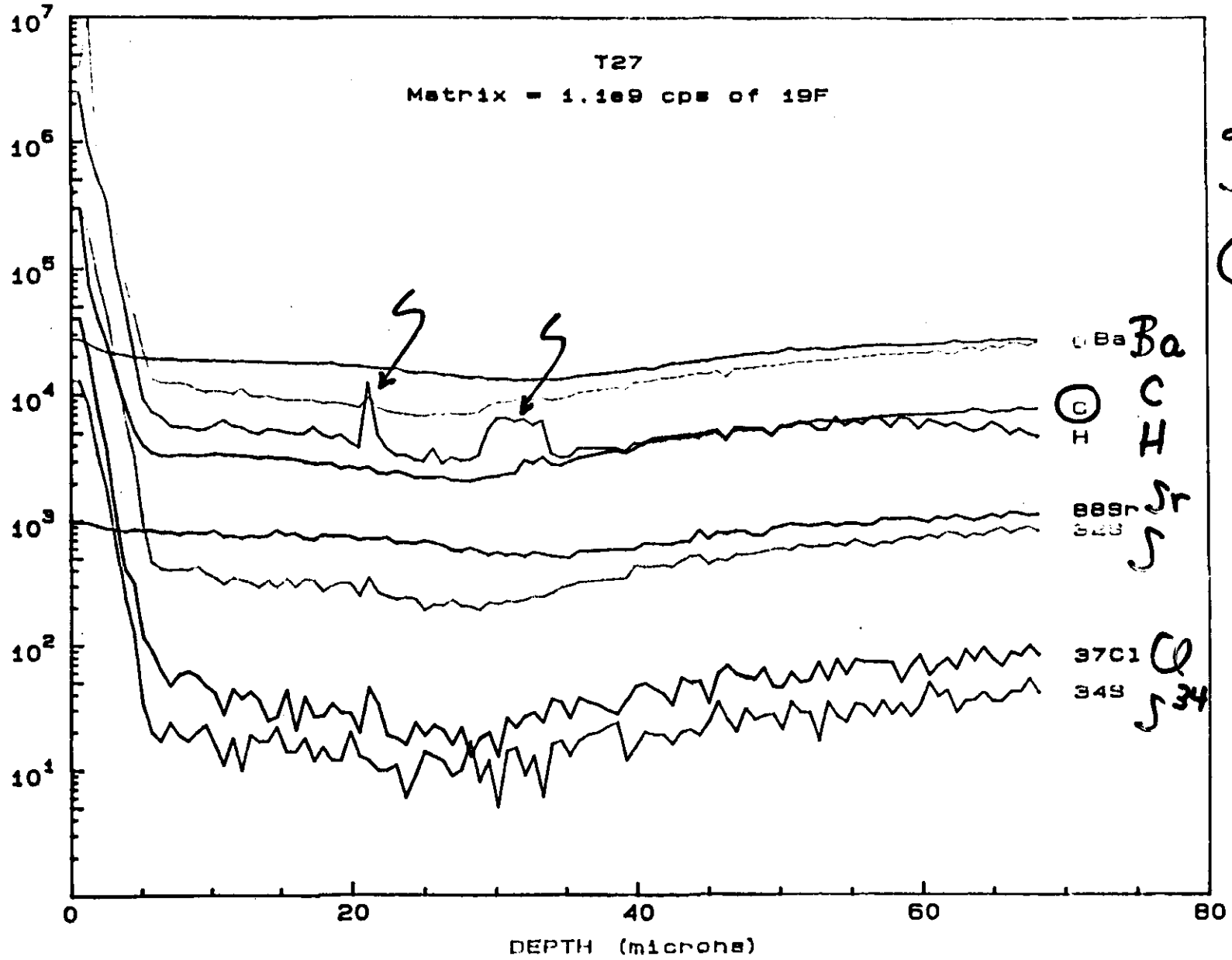


Fig. 2 : Carbon

Fig #2

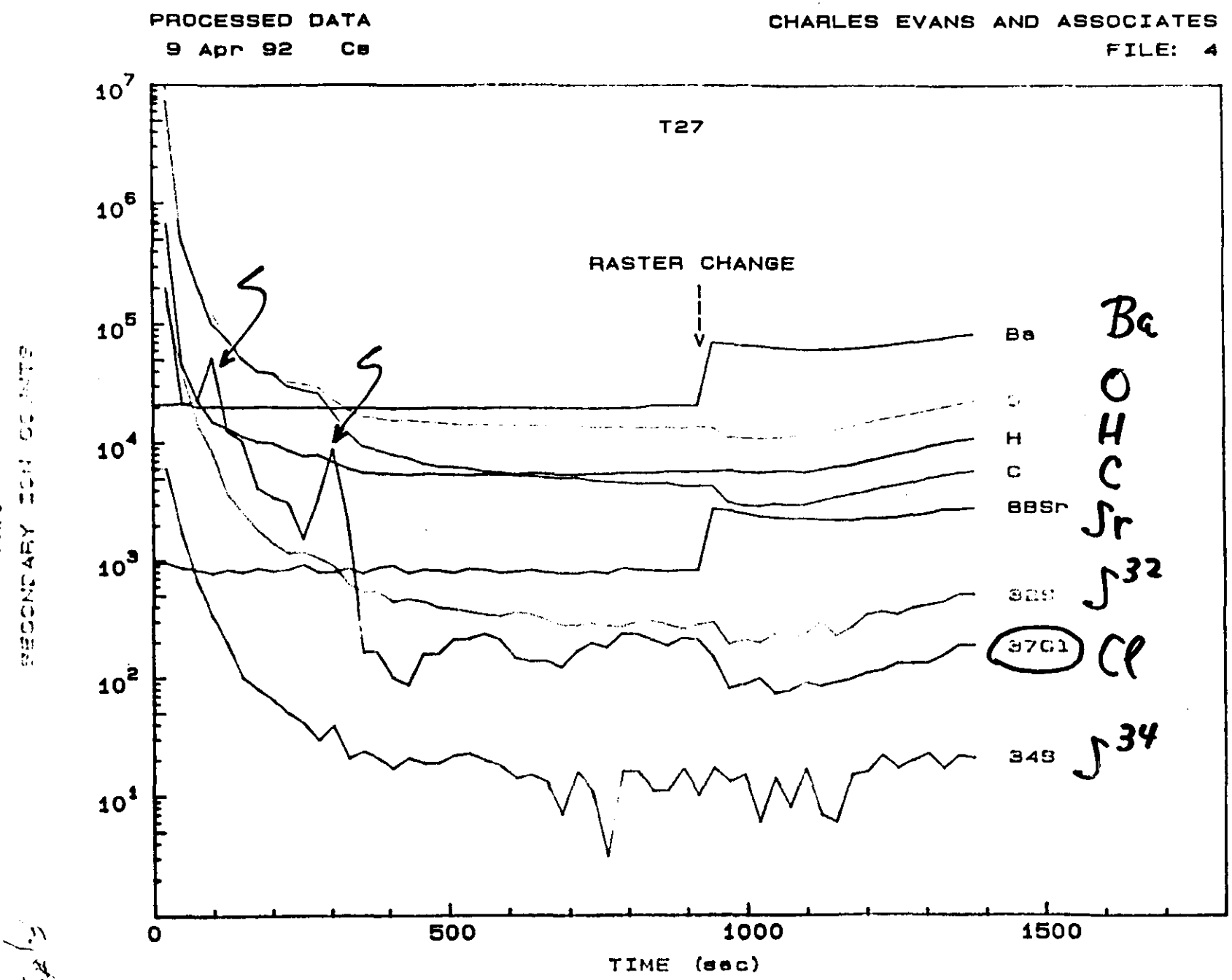
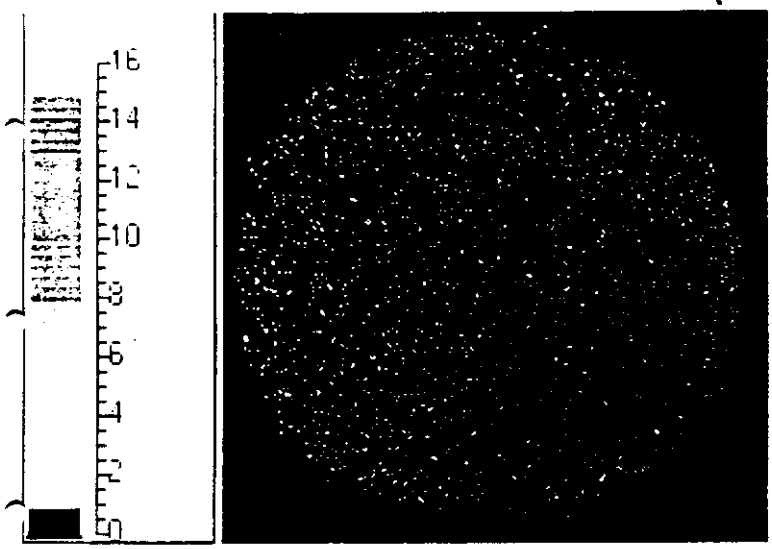


Fig. 3: Chlorine Inclusion

Fig. 5

Elemental

- Imaging: 150 μm × 150 μm Field
- Slice T27



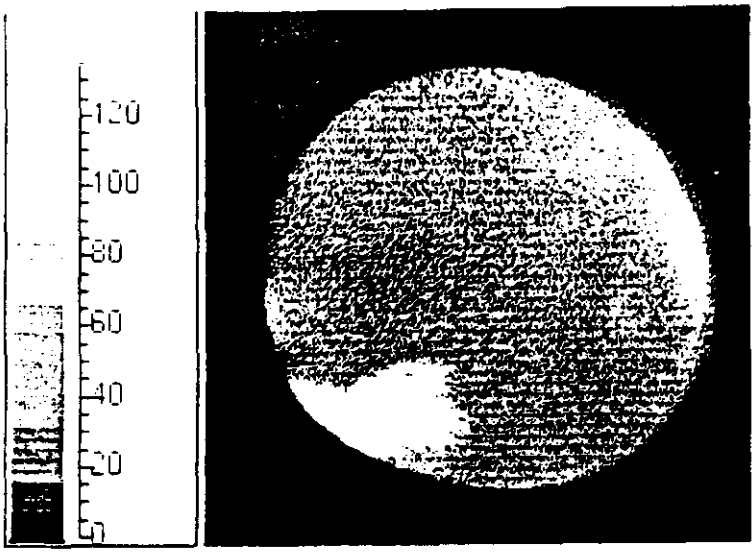
File Name:
BLANK
Type:

Status:
Saved On Disk
Spectrum:
Unknown
Image Scale:
Not Available

- Background Measurement

Comments: RAE Background, Mass 0.5, 60 sec int

- 2 MCPs + xy Detector
- Image 1 Element at a Given Depth



File Name:
HBA1
Type:

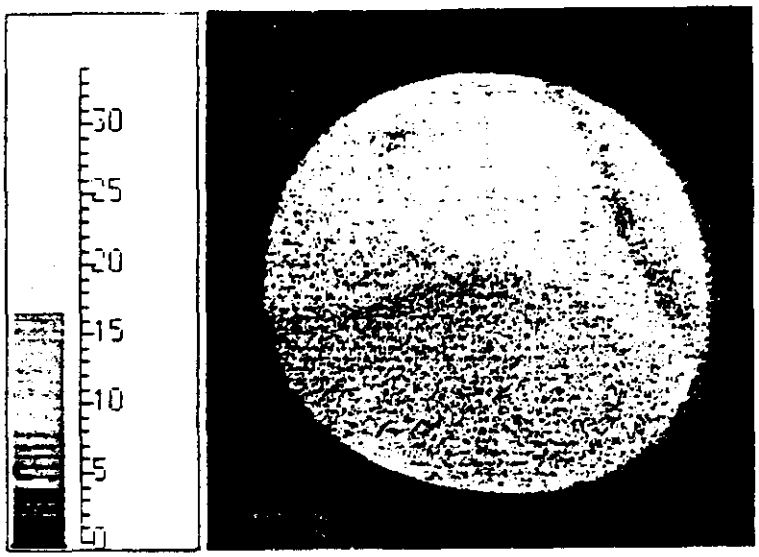
Ba^{138}

Status:
Saved On Disk
Spectrum:
Unknown
Image Scale:
Not Available

70'clock Hot Spot

3 o'clock

Comments: Area A, 138 Ba, 60 sec int



File Name:
AF1
Type:

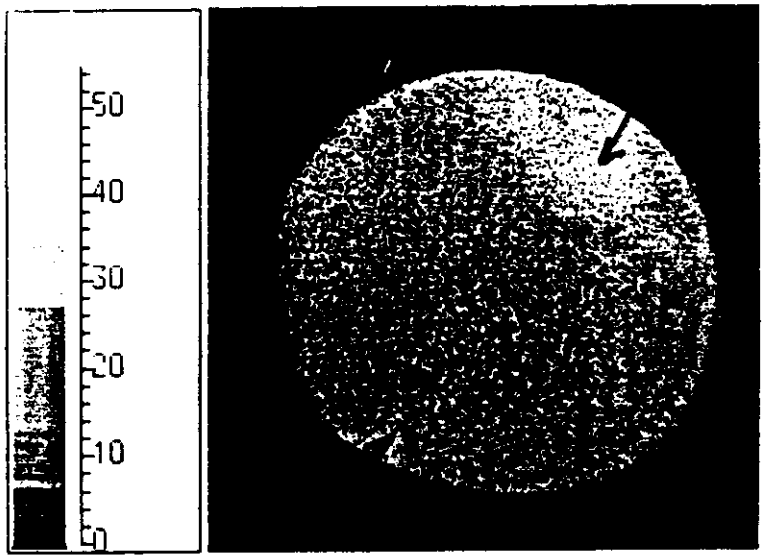
F^{19}

Status:
Saved On Disk
Spectrum:
Unknown
Image Scale:
Not Available

Lack of Correlation:

Comments: Area [illegible], 60 sec int

Note: Non-Stoichiometric Regions

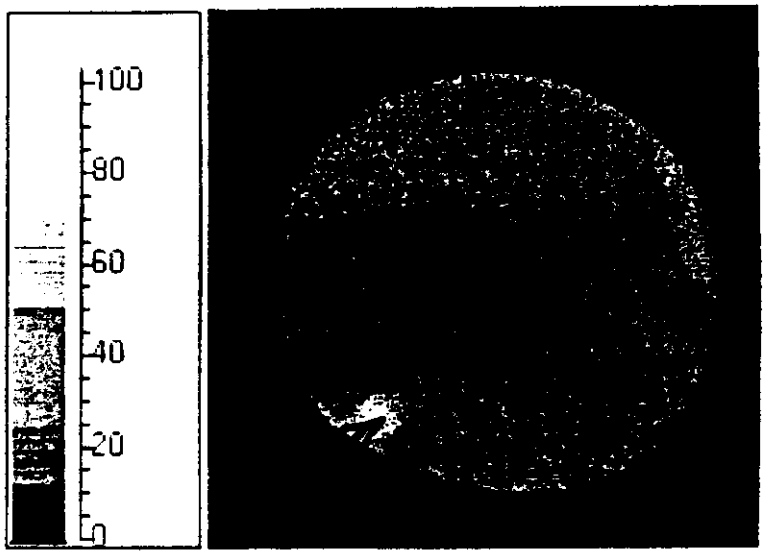


File Name:
AH1
Type:

H (3 o'clock)

Status:
Saved On Disk
Spectrum:
Unknown
Image Scale:
Not Available

Comments: Area A, 1H, 60 sec int



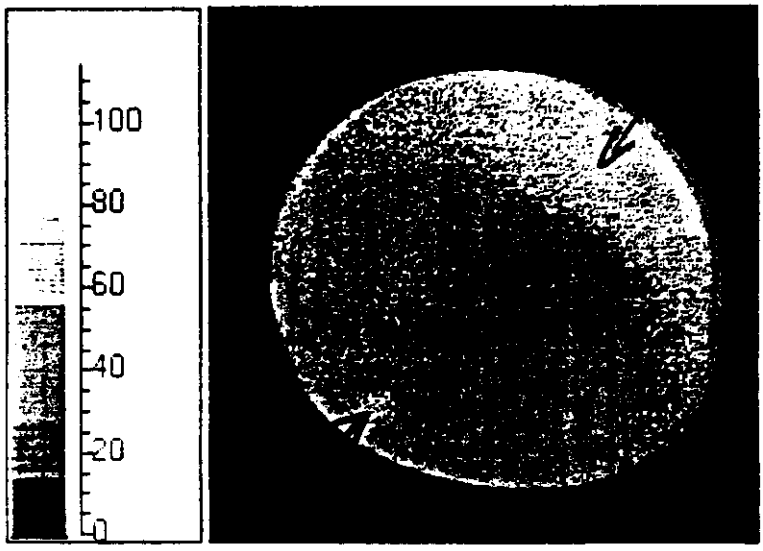
File Name:
AC1
Type:

C^{12} (7 o'clock)

Status:
Saved On Disk
Spectrum:
Unknown
Image Scale:
Not Available

[Ba Correlation]

Comments: Area A, 12C, 60 sec int



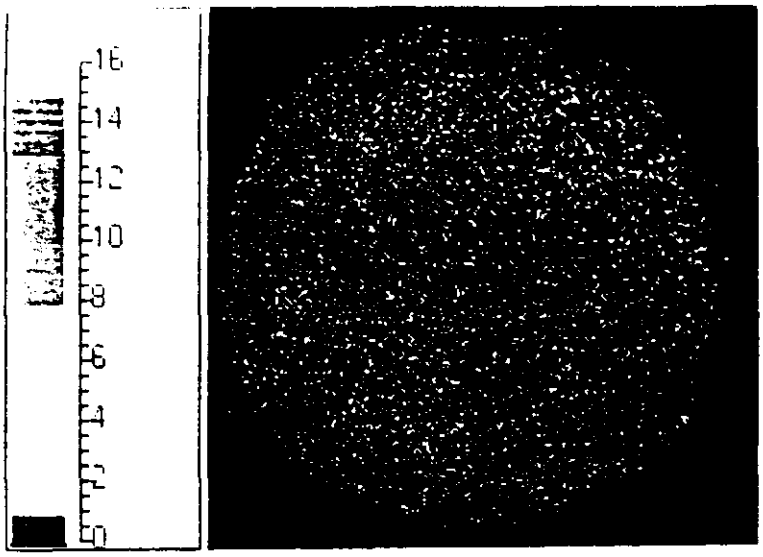
File Name:
AO1
Type:

O (7 o'clock)

Status:
Saved On Disk
Spectrum:
Unknown
Image Scale:
Not Available

[OH Correlation:]
→ OH^-

Comments: Area A, 16O, 60 sec int

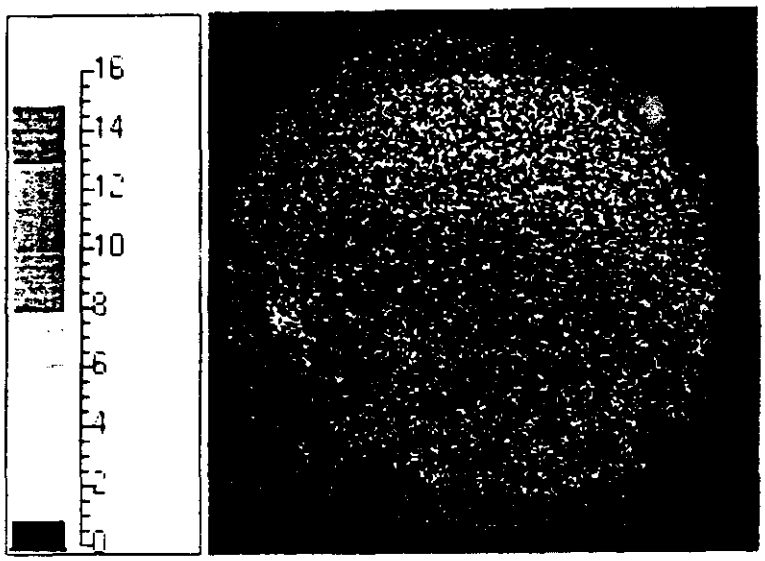


File Name:
AS1
Type:

Status:
Saved On Disk
Spectrum:
Unknown
Image Scale:
Not Available

S

Comments: Area A, 34S, 60 sec int



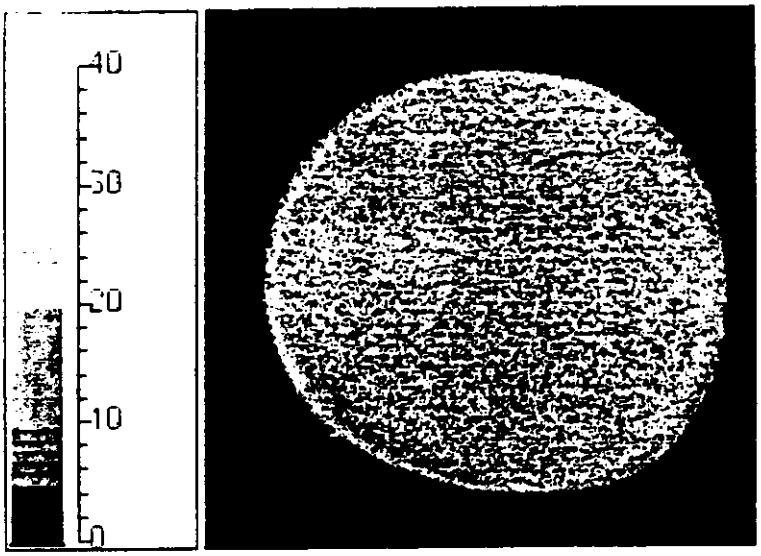
File Name:
ACL1
Type:

Status:
Saved On Disk
Spectrum:
Unknown
Image Scale:
Not Available

Cl:

Comments: Area A, 3[illegible], 60 sec int

[Correlate With O, H]
[9 o'clock: no correlation]

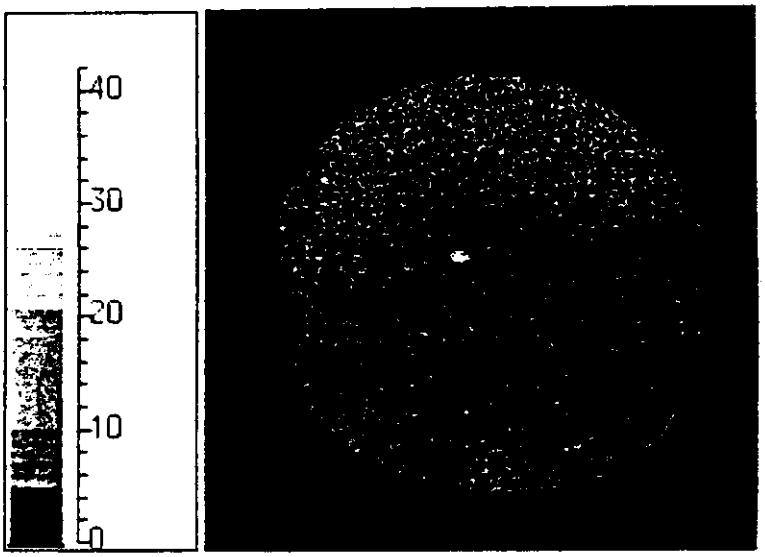


File Name:
BBA1
Type:

Status:
Saved On Disk
Spectrum:
Unknown
Image Scale:
Not Available

Ba^{138}

Comments: Area B, 138Ba, 60 sec int



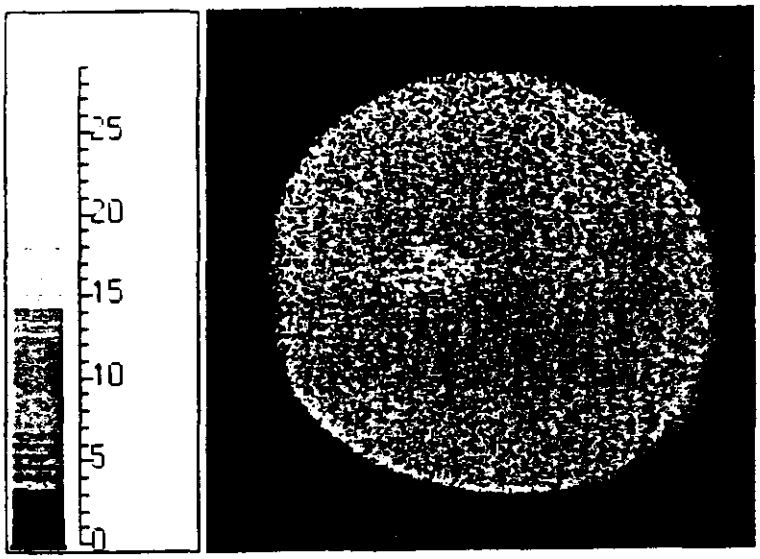
File Name:
BF1
Type:

F^{19}

Status:
Saved On Disk
Spectrum:
Unknown
Image Scale:
Not Available

[HOT SPOT BEGINS]

Comments: Area B, 19F, 60 sec int

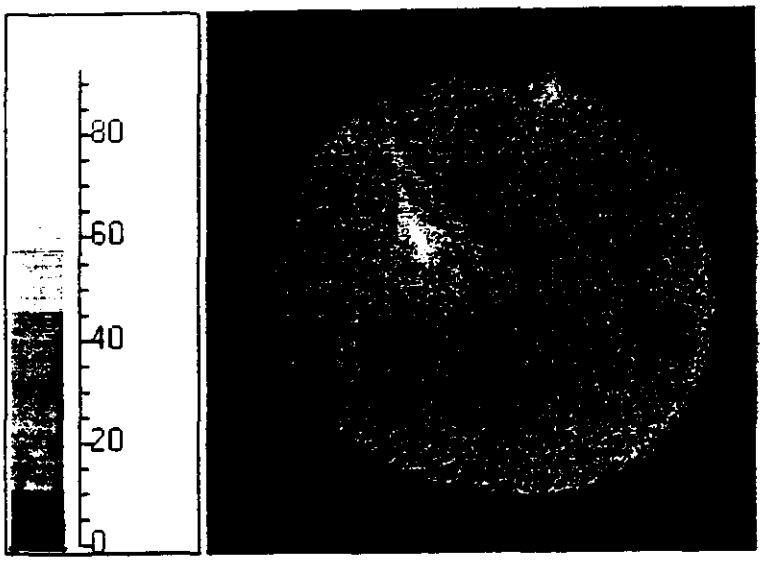


File Name:
BH1
Type:

Status:
Saved On Disk
Spectrum:
Unknown
Image Scale:
Not Available

H

Comments: Area B, 1H, 60 sec int

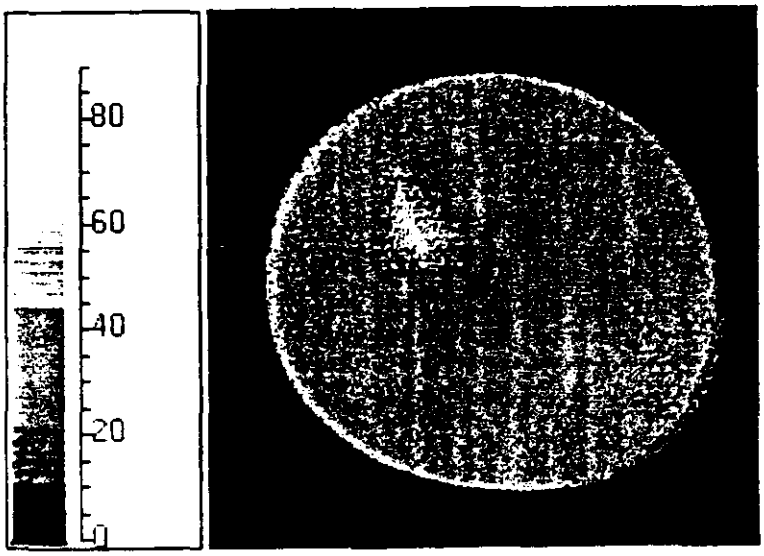


File Name:
BC1
Type:

Status:
Saved On Disk
Spectrum:
Unknown
Image Scale:
Not Available

C

Comments: Area B, 12C, 60 sec int



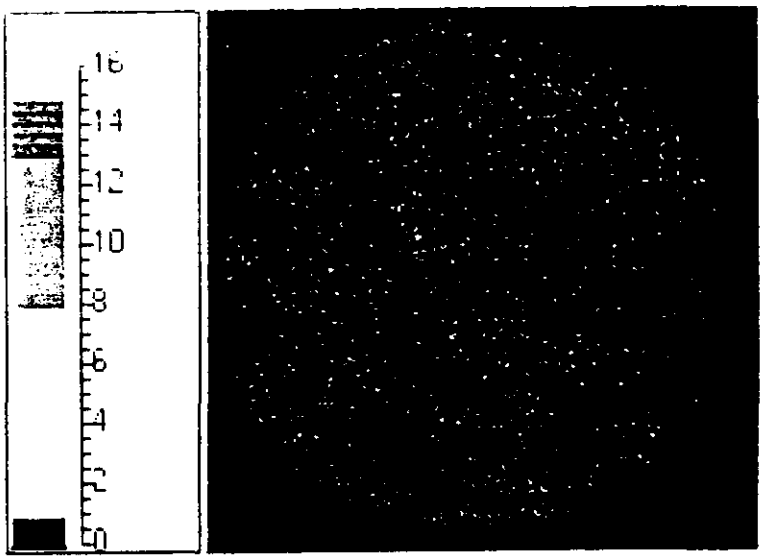
File Name:
B01
Type:

B

Status:
Saved On Disk
Spectrum:
Unknown
Image Scale:
Not Available

[CORRELATED HOT SPOT]

Comments: Area B, 160, 60 sec int

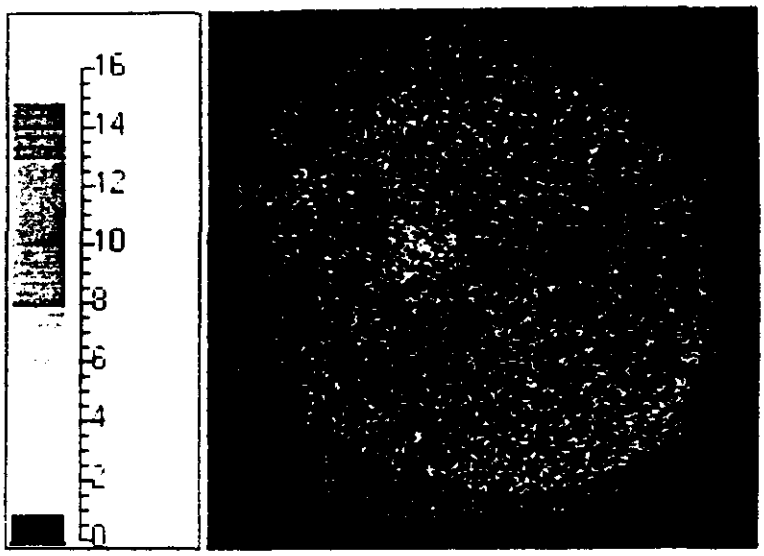


File Name:
BS1
Type:

Status:
Saved On Disk
Spectrum:
Unknown
Image Scale:
Not Available

S^{34}

Comments: Area B, 34S, 60 sec int



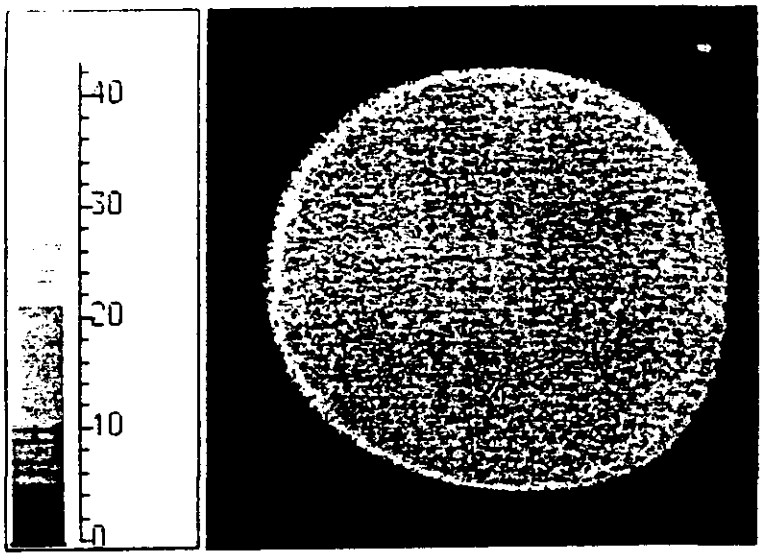
File Name:
BCL1
Type:

Status:
Saved On Disk
Spectrum:
Unknown
Image Scale:
Not Available

Cl^{37}

[CORRELATED HOT SPOT]

Comments: Area B, 37Cl, 60 sec int

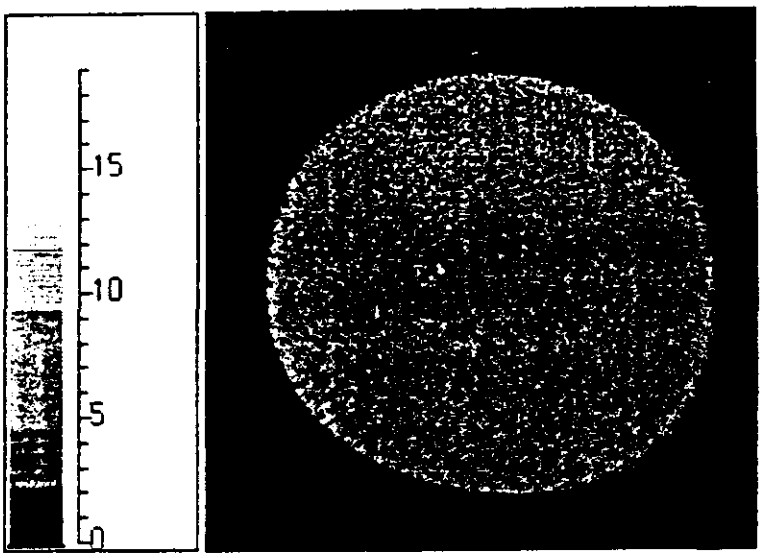


File Name:
CBA1
Type:

Status:
Saved On Disk
Spectrum:
Unknown
Image Scale:
Not Available

Ba^{138}

Comments: Area C, 138Ba, 60 sec int



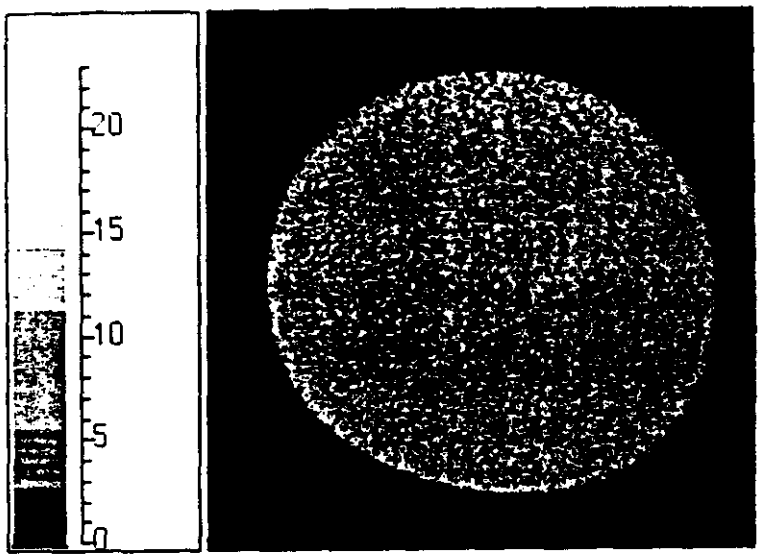
File Name:
CF1
Type:

Status:
Saved On Disk
Spectrum:
Unknown
Image Scale:
Not Available

F^{19}

Comments: Area C, 19F, 60 sec int

[End of Hot Spot]

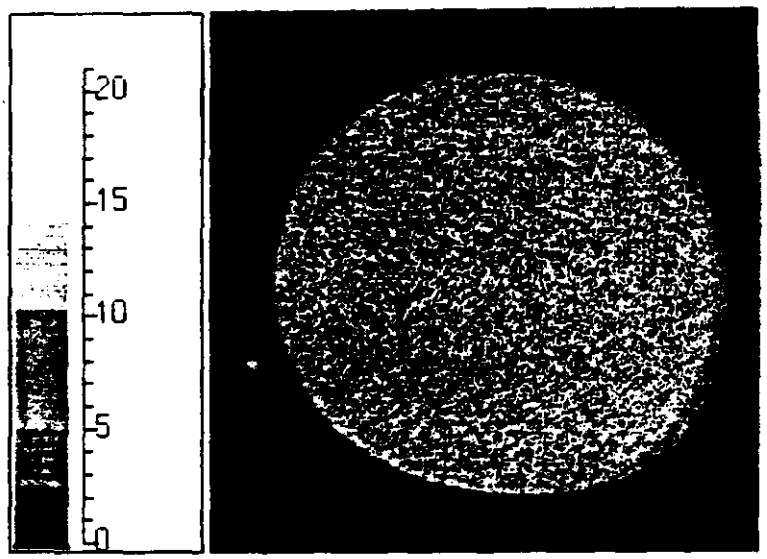


File Name:
CH1
Type:

Status:
Saved On Disk
Spectrum:
Unknown
Image Scale:
Not Available

H

Comments: Area C, 1H, 60 sec int

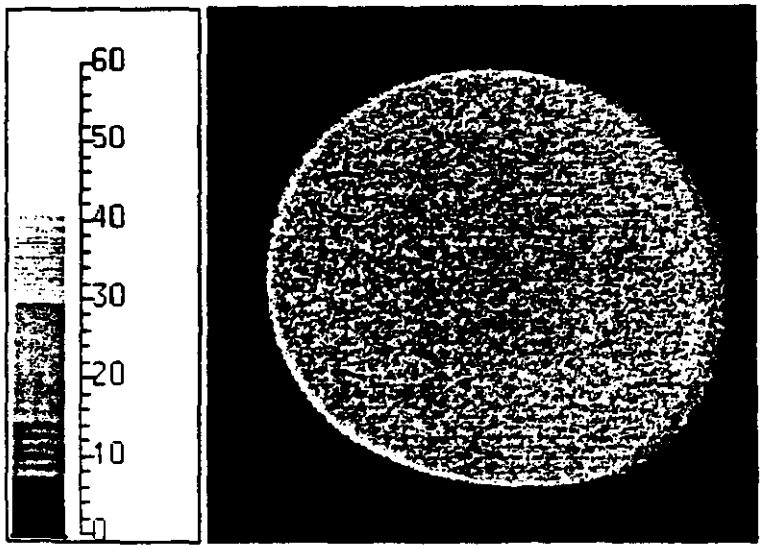


File Name:
CC1
Type:

Status:
Saved On Disk
Spectrum:
Unknown
Image Scale:
Not Available

C^{12}

Comments: Area C, 12C, 60 sec int



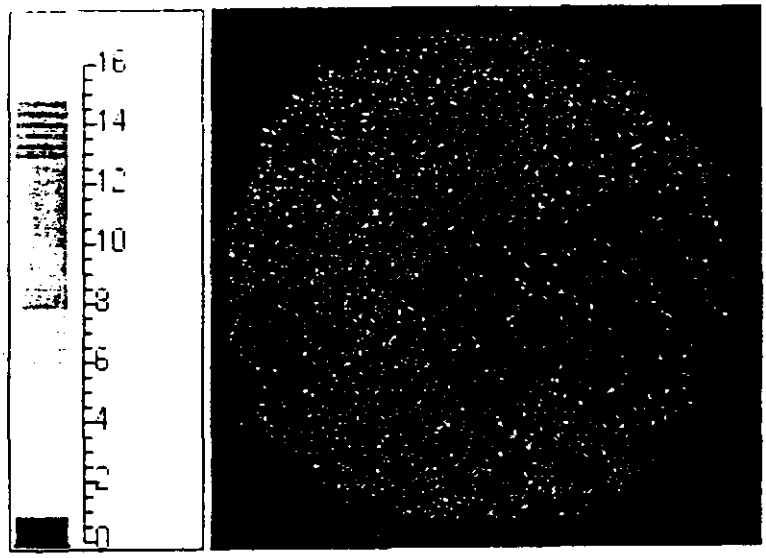
File Name:
CO1
Type:

O^{16}

Status:
Saved On Disk
Spectrum:
Unknown
Image Scale:
Not Available

[UNIFORM]

Comments: Area C. 16O. 60 sec int

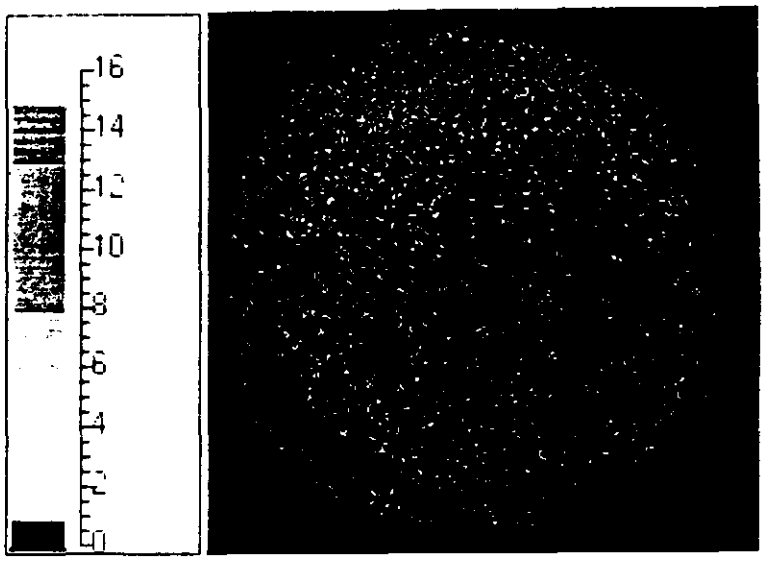


File Name:
CS1
Type:

Status:
Saved On Disk
Spectrum:
Unknown
Image Scale:
Not Available

S^{34}

Comments: Area C, 34S, 60 sec int



File Name:
CCL1
Type:

Status:
Saved On Disk
Spectrum:
Unknown
Image Scale:
Not Available

Cl^{37}

Comments: Area C, 37Cl, 60 sec int

[UNIFORM:
Inclusion Past]

NEXT: • NEW CRYSTAL SLICES
• Rare EARTH IMAGING

SIMS IMAGING

Summary:
1 The SIMS images suggest that there are microscopic variations in the lateral chemical composition of the BaF2 crystals. The 2 variation of oxygen is sometimes correlated with carbon and at other times correlated with hydrogen. Thus measurement of the total oxygen concentration may not give a clear picture of the oxygen which is optically active in the crystal. 3 Processing parameters may effect the chemical state of the oxygen in the crystal and thus change the optical response of the material.

All of these images were acquired from the near surface of the cleave. It may be useful to sputter into a crystal cleaved face for several microns in the depth profiling mode (as in figure #3) until a precipitate is found. Then [the SIMS instrument could be used to image the precipitate at depth in the crystal.]

SIMS:
I have recently sent a formal report to Harvey on the SIMS imaging of a crystal from the prototype (1 of 19) crystals. In summary, we found the material to be microscopically (on the order of 10 to 20 microns) non uniform. There were clearly defined regions of increased fluorine, carbon, oxygen, hydrogen, sulfur, and chlorine. The images have been sent to Caltech

RBS/ARC Image:
The most recent crystal is similar in surface damage to other crystals. We will continue to investigate the interior crystallinity.

• NEW CRYSTAL TENDS to HAVE MORE SINGLE-CRYSTAL DOMAINS (CRYSTAL STRUCTURE NOT AS GOOD?)

FROM: Michael D. Strathman

SUBJECT: Analysis of BaF2 ∴ NEWER ('92) VS. Older CRYSTAL ANALYSIS

In this Fax I will include some of the most recent results we have obtained on BaF2.

GDMS:

181

I have included a comparison between the GDMS analysis of the most recent crystal (S52) and an old crystal designated SIC-XTL. Note that the new crystal (S52) has dramatically less Sr, 14,000ppmw verses 420ppmw. Note also that there has been a big reduction in the amount of heavy and transition elements in the new crystal. For example SIC-XTL has on the order of Ce(0.07ppmw), Yb(2ppmw), and Lu(1ppmw) where as for the new crystal (S52) all of these elements are below background, Ce(<0.015ppmw), Yb(<0.071ppmw), and Lu(<0.0067). I would state that this is a very detectable difference between the two crystals.

The sulfur and chlorine seem to be in the same range for the new crystal. I will be doing other analysis to confirm this result.

Date: 1/16/92
Analyst: W.A. Vieth

TABLE 5

SIC (Early 1991)

GDMS Analysis Results of One BaF_2 Glass Sample #SIC-XTL, Base Cleaved

Element	Concentration (ppmw)	Element	Concentration (ppmw)
Li	<0.003	Rh[1]	<120.
Be	<0.004	Pd[2]	<0.1%
B	0.3	Ag	BINDER
C	(<870.)	Cd	<1.
N	(≤1.7%)	In	0.04
O	(≤1.1%)	Sn	0.9
F	MATRIX	Sb[3]	<110.
Na	~4.	Te[4]	<280.
Mg	1.	I[5]	<130.
Al	12.	Cs[6]	<2.8
Si	10.-40.	Ba	MATRIX
P	0.6	La[6]	<33.
S[7]	~90.	Ce	0.07 ←
Cl[7]	~210.	Pr[8]	0.2 ←
K	<0.8	Nd[8]	1.6 ←
Ca[9]	~70.	Sm[8]	<28.
Sc	<0.01	Eu[8]	<0.1%
Ti	<0.1	Gd[8]	1.3 ←
V	<0.004	Tb[8]	0.3 ←
Cr	<0.1	Dy[8]	≤3.4
Mn	<0.008	Ho[8]	0.1 ←
Fe	<0.5	Er[8]	0.1 ←
Co	<0.005	Tm[8]	0.2 ←
Ni	<0.1	Yb[8]	2. ←
Cu	<0.2	Lu[8]	1. ←
Zn	<0.2	Hf	0.7 ←
Ga	<0.04	Ta[10]	<25.
Ge	<0.1	W	<0.02
As	<1.	Re	<0.03
Se[11]	<0.7	Os	<0.03
Br	<0.6	Ir	<0.02
Rb[2]	<0.2	Pt	<0.04
Sr[2]	1.3% !	Au	<0.2
Y[2]	<2.	Hg	≤0.5
Zr	<0.01	Tl	<0.04
Nb	<0.01	Pb	<0.1
Mo	<0.6	Bi	<0.01
Ru	<0.1	Th	<0.002
		U	<0.007

Rare Earths

Date: 1/16/92
Analyst: W.A. Vieth

TABLE 6

SIC

GDMS Analysis Results of One BaF_2 Glass Sample #SIC-XTL, Tip, Cleaved

Element	Concentration (ppmw)	Element	Concentration (ppmw)
Li	<0.005	Rh[1]	<84.
Be	<0.004	Pd[2]	<440.
B	0.2	Ag	BINDER
C	(<0.17%)	Cd	<0.7
N	(≤0.9%)	In	<0.2
O	(≤1.7%)	Sn	≤0.5
F	MATRIX	Sb[3]	<90.
Na	3.	Te[4]	<200.
Mg	0.3	I[5]	<190.
Al	6.	Cs[6]	<1.5
Si	6.	Ba	MATRIX
P	0.4	La[6]	<15.
S[7]	~60.	Ce	0.2
Cl[7]	~100.	Pr[8]	0.4
K	<0.4	Nd[8]	2.
Ca[9]	~50.	Sm[8]	<9.
Sc	<0.01	Eu[8]	<0.16%
Ti	<0.1	Gd[8]	2.
V	<0.03	Tb[8]	0.4
Cr	<0.09	Dy[8]	≤3.
Mn	<0.04	Ho[8]	0.08
Fe	<0.5	Er[8]	0.5
Co	<0.006	Tm[8]	0.3
Ni	<0.1	Yb[8]	2.
Cu	<0.2	Lu[8]	2.
Zn	<0.2	Hf	0.3
Ga	<0.07	Ta[10]	<21.
Ge	<0.06	W	<0.07
As	<0.5	Re	<0.06
Se[11]	<0.7	Os	<0.04
Br	<0.4	Ir	<0.04
Rb[2]	<0.3	Pt	<0.1
Sr[2]	1.3% !	Au	<0.09
Y[2]	<2.	Hg	<0.2
Zr	<0.01	Tl	<0.05
Nb	<0.01	Pb	<0.08
Mo	<0.4	Bi	<0.05
Ru	<0.05	Th	<0.004
		U	<0.01

SDMS: TRACE Element Survey

Date: [illegible]
Analyst: W.A. Vieth

TABLE 2

KORTH

SDMS Analysis Results of One BaF_2 Glass Sample #K458484A, inside cleaved

Element	Concentration (ppmw)	Element	Concentration (ppmw)
Li	<0.002	Rh	<0.6
Be	<0.002	Pd[1]	<4.
B	0.8	Ag	BINDER
C	(≤440.)	Cd	<0.2
N	(<1.7%)	In	0.09
O	(≤1.8%)	Sn	<0.2
F	MATRIX	Sb[2]	<80.
Na	3.	Te[3]	<220.
Mg	0.1	I[4]	<65.
Al	≤1.	Cs[5]	<1.8
Si	24.	Ba	MATRIX
P	0.5	La[5]	<22.
• S[6]	~70.	Ce	<0.01
• Cl[6]	~100.	Pr[7]	0.2 ←
K	<0.2	Nd[7]	1. ←
Ca	3.	Sm[7]	<4.
Sc	<0.01	Eu[7]	<800.
Ti	<0.1	Gd[7]	0.5 ←
V	0.004	Tb[7]	0.1 ←
Cr	<0.04	Dy[7]	≤1.6
Mn	<0.01	Ho[7]	0.07 ←
Fe	<0.4	Er[7]	0.03 ←
Co	<0.003	Tm[7]	0.04 ←
Ni	<0.1	Yb[7]	0.2 ←
Cu	<0.1	Lu[7]	<0.3
Zn	<0.2	Hf	0.9 ←
Ga	<0.04	Ta[8]	<40.
Ge	<0.04	W	<0.2
As	<0.5	Re	<0.02
Se[9]	<0.2	Os	<0.005
Br	<0.2	Ir	<0.002
Rb[1]	<0.03	Pt	<0.02
• Sr[1]	160.	Au	<0.09
Y[1]	<0.4	Hg	≤0.3
Zr	<0.005	Tl	<0.03
Nb	<0.002	Pb	<0.08
Mo	<0.5	Bi	<0.02
Ru	<0.01	Th	<0.001
		U	<0.004

Rare Earths

Table 1. GDMS analysis results of 1 barium fluoride sample #S52

SIC NEW

Analyzed by W.A.Vieth, 5/14/92.

Slice From end of 20cm Crystal

Element		Concentration (ppm except as noted)		Element		Concentration (ppm except as noted)	
Li	<	0.015		Pd	<	0.70	
Be	<	0.0035		Ag		170	%
B	<	0.13		Cd	<	0.93	
C	<	640		In		0.18	
N	<	0.88	%	Sn	<	1.	
O	<	0.59	%	Sb	<	3.9	
F		MATRIX		I	<	47	
Na		3.		Te	<	3.5	
Mg		0.4		Cs	<	1.2	
Al		24.		Ba		MATRIX	%
Si	<	30.		La	<	4.9	
P		0.4		Ce	<	0.015	
• S	~	150		Pr	≤	0.20	
• Cl	~	100		Nd	≤	0.31	
K	<	0.53		Sm	<	52	
Ca	≤	10.		Eu	<	680	
Sc	≤	0.0016		Gd	<	0.11.	
Ti	<	0.26		Tb	<	0.014	
V	<	0.027		Dy	<	0.094	
Cr	<	0.024		Ho	<	0.010	
Mn	<	0.016		Er	<	0.025	
Fe	<	0.47		Tm	<	0.0077	
Co	<	0.0079		Yb	<	0.071	
Ni	<	0.055		Lu	<	0.0067	
Cu		1.7		Hf	<	0.028	
Zn	<	0.26		Ta	<	28	
Ga	<	0.058		W	<	0.2	
Ge	<	0.022		Re	<	0.027	
As	<	0.8		Os	<	0.037	
Se	<	0.21		Ir	<	0.056	
Br	<	0.22		Pt	<	0.017	
Rb	<	0.24		Au	<	0.043	
• Sr		420		Hg	<	0.13	
Y	<	1.0		Tl	<	0.031	
Zr		0.7		Pb	<	0.16	
Nb	<	0.3		Bi	<	0.026	
Mo	<	0.9		Th	≤	0.004	
Ru	<	0.031		U	≤	0.002	
Rh	<	2.7					

"NO" RARE EARTHS

Table 2. GDMS analysis results of 1 barium fluoride sample #S52-T

SIC NEW

Analyzed by W.A.Vieth, 5/14/92.

Slice from Other End of 20cm Crystal

Element		Concentration (ppm except as noted)		Element		Concentration (ppm except as noted)	
Li	<	0.0095		Pd	<	0.63	
Be	<	0.0029		Ag		190	%
B	<	0.068		Cd	<	2.0	
C	<	1100		In		0.099	
N	<	1.1	%	Sn	<	1.6	
O	<	0.76	%	Sb	<	13	
F		MATRIX		I	<	45	
Na	<	3.		Te	<	72	
Mg		0.25		Cs	<	1.9	
Al		6.		Ba		MATRIX	
Si	<	10.		La	<	3.9	
P		0.4		Ce	<	0.044	
S	~	60.		Pr	<	0.17	
Cl	~	100.		Nd	<	0.39	
K		0.6		Sm	<	29	
Ca	≤	6.		Eu	<	1200	
Sc	<	0.0013		Gd	<	0.11	
Ti	<	0.1		Tb	<	0.016	
V	<	0.0067		Dy	<	0.091	
Cr	<	0.076		Ho	<	0.012	
Mn	<	0.024		Er	<	0.026	
Fe	<	2.		Tm	<	0.013	
Co	<	0.0068		Yb	<	0.092	
Ni	<	0.1		Lu	<	0.016	
Cu		0.9		Hf	<	0.044	
Zn	<	0.41		Ta	<	32.	
Ga	<	0.023		W	<	0.3	
Ge	<	0.047		Re	<	0.029	
As	<	0.72		Os	<	0.018	
Se	<	0.59		Ir	<	0.012	
Br	<	0.22		Pt	<	0.034	
Rb	<	0.55		Au	<	0.053	
Sr		360.		Hg	<	0.077	
Y	<	0.88		Tl	<	0.025	
Zr	<	0.049		Pb	<	0.1	
Nb	<	0.6		Bi	<	0.033	
Mo	<	1.		Th	<	0.0027	
Ru	<	0.0069		U	<	0.0019	
Rh	<	1.7					

"NO" Rare Earths

FROM: Michael D. Strathman

SUBJECT: Quantitation of SIMS Data

We have analysed the ion implanted BaF2 samples computed the appropriate Relative Sensitivity Factors (RSF's). This allows us to quantitative the previously reported SIMS data. Color plots on concentration scales will follow in a report next week.

Attached to this FAX are data summarized in Tables 1-4:

SIMS

- Table 1: Oxygen Bulk data 01/14/92
- Table 2: Elemental Bulk data 03/19/92
- Table 3: Elemental Bulk data 04/01/92
- Table 4: Elemental Bulk data 05/18/92

→ "Bulk" HERE MEANS Microscopic Base Level

• 1 mm³ • Scan ~50μm Beam

Also attached is a summary figure of the Leco and SIMS data take from the T Series crystal, Prototype (1 of 19). This figure was generated by taking the elemental concentration from a given slice, plotting it on the graph and then extending that concentration until data from an other sample was available. Note that the number of samples is different for the SIMS and Leco data. Of particular interest is the spike up in the Leco sulfur and oxygen concentration at slice 19. This is followed by an increase in the SIMS oxygen and hydrogen concentration at slice 23. I wonder SIMS data were available for slice 19 would the oxygen jump up even more? I will try to acquire more SIMS data in the near future.

• LECO → Gas Fusion

Analyses Performed on 14-JAN-92

	Sample	[O] (ppmw)	
	SIC XTL BASE	1.6	← Early SIC 1991 Quality
KORTH	K458484A	2.9	KORTH
KORTH	K458484A	2.8	KORTH
KORTH	K144170	1.5	KORTH
	BAF SIC 2X2.5	1.5	
	SIC XTL TIP	0.9	← Early SIC 1991 QUALITY
	SIC CUBE	2.9	Older SIC

- SIMS: Oxygen Content <1-3 ppm

* → (away FROM INCLUSIONS)

Bulk Concentrations (ppmw)

Analyses Performed on 1-APR-92

≲0.3 ppmW <1 ppmW 0.5-1.2 TPMW < 0.1 ppmW ≲0.2 ppmW

Sample	File	H	C	N	O	S	Cl	Sr
CE&A FZ	1	0.11	0.20	0.061	1.4	0.012	0.068	
	14	0.093	0.18	0.047	0.92	0.010	0.042	
SIC XTL TIP	2	0.14	0.28	0.052	0.55	0.027	0.17	8600
SIC CUBE	3	0.19	0.46	0.060	1.0	0.041	0.050	9400
	13	0.15	0.22	0.021	0.59	0.020	0.020	7600
T1	4	0.15	0.33	0.067	0.73	0.030	0.048	8700
T3B	5	0.16	0.32	0.046	0.66	0.031	0.070	11000
T7	6	0.078	0.34	0.062	0.85	0.030	0.047	8100
	9	0.057	0.21	0.013	0.51	0.021	0.036	7500
T19	7	0.27	0.59	0.043	1.2	0.052	0.18	14000
	10	0.14	0.26	0.011	0.69	0.024	0.11	9500
T23B	15	0.18	0.23	0.009	0.62	0.028	0.11	10000
T27	8	0.26	0.44	0.076	1.1	0.044	0.22	6000
	12	0.070	0.18	0.019	0.52	0.018	0.11	5300

Older

SLICES of "FNAL" CRYSTAL

• NOTE Variations

Large

SIC NEW

Bulk Concentrations (ppmw)

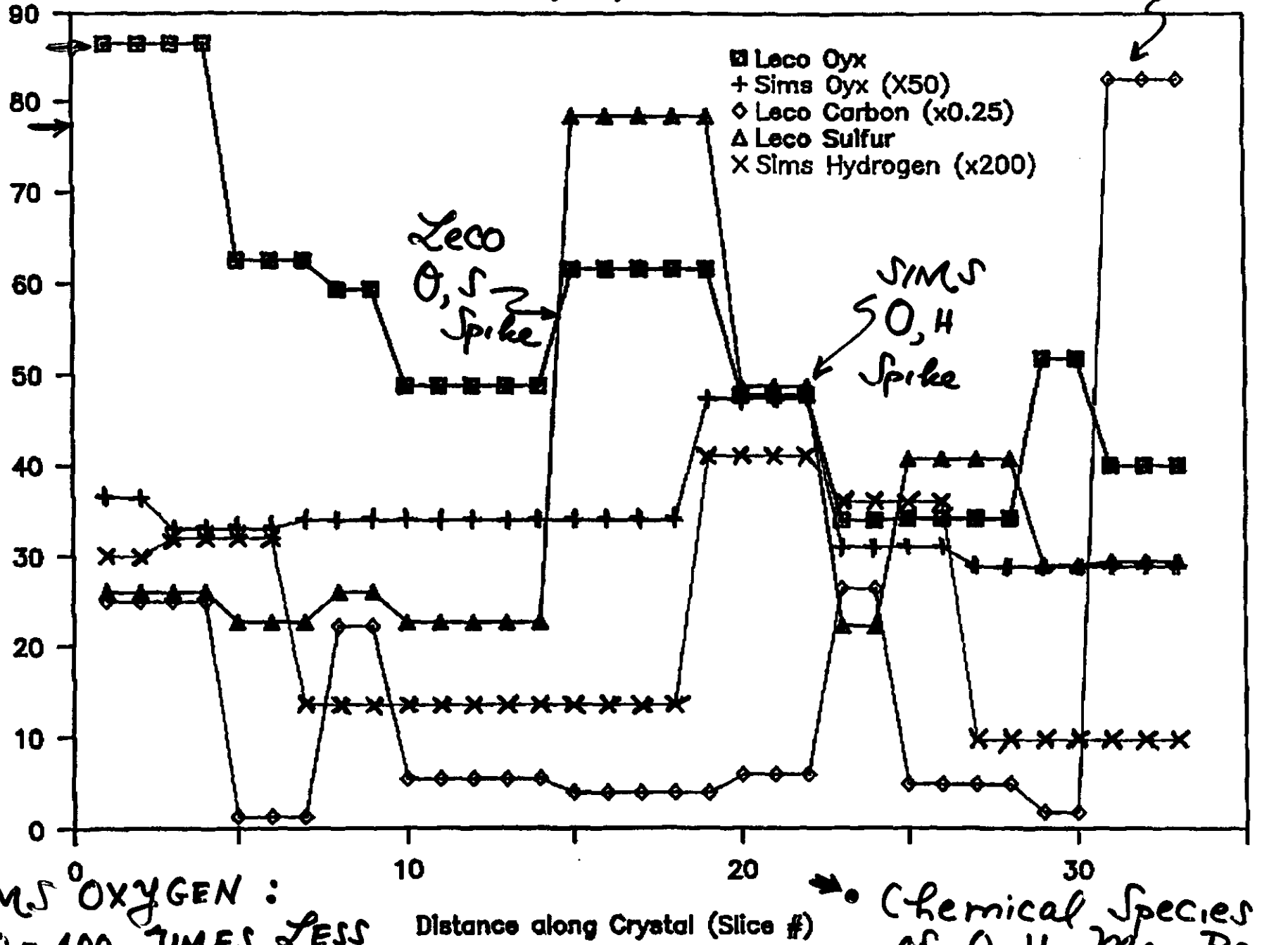
Analyses Performed on 18-MAY-92

Sample	File	H	C	N	O	S	Cl	Sr
CE&A FZ	10	0.060	0.24	0.020	0.96	0.005	0.038	
S52-E2	11	0.12	0.99	0.11	2.0	0.070	0.17	260
	12	0.12	0.67	0.014	1.3	0.082	0.084	190
S52-E1	13	0.054	0.56	0.020	1.2	0.050	0.062	184
	14	0.12	0.84	0.10	1.7	0.080	0.12	318

Larger? Less

Prototype Crystal (1 of 19)

Gas Fusion (Leco) and SIMS Data



- SIMS OXYGEN : 50 - 100 TIMES LESS THAN LECO OXYGEN
- Chemical Species of O, H May Be Crucial

BaF_2 R&D May 1992: MATERIALS ANALYSIS, MANUFACTURE

- CHARLES EVANS & ASSOCIATES
  - Inclusions Decorating Dislocation Boundaries: Impurities Highly Localized.
  - SIMS: Depth Profiling, Elemental Imaging, and Correlation of Impurities.
  - Quantitation of O,N,C,H,S in "FNAL" Crystal Cleaved in Slices:
    - Microscopic (SIMS) Base Level 0.5 - 3 ppmw
    - Global Level 50 - 100 ppmw
    - Dominance of Inclusions
  - New SIC Versus Older Crystals: GDMS
    - "No" Rare Earths
    - Other Trace Elements Similar
    - RBS: May Be Less Monocrystalline
  - SIMS, Gas Fusion on New SIC Crystal Underway
- LLNL – SMALL ULTRA-PURE CRYSTAL GROWTH
  - Ultra-Pure Materials
  - Multipass Zone-Refining
  - Reactive Atmosphere
  - Tests at CE&A, Caltech, BNL By End June
- LLNL: SURFACE LAPPING, POLISHING, COATING
  - Diamond-Impregnated Pitch Polish Chosen:
    - Roughness 10 A° RMS; Surface Structure
    - Flatness "One-Tenth Wave"
    - Coating: 90% Reflectance (220 nm)
    - Manufacture: Jigs, Process, Machine Designed
    - Technology Transfer: China Trip in June

gem

γeμ

Presentation by:

R. Zhu

BaF_2 Progress in China

Ren-yuan Zhu

June 4, 1992

GEM Council Meeting

K. Zhu

Work done at SIC

TEM study

Transmission Electron Microscopy

TEM observation and electron diffraction

Experiment condition: 200KV, 20-30 μA

Vacuum: 10^{-7} torr.

An electron beam of diameter of 1000Å focused on crystal.

Every 2 minutes tooK a picture.

Samples: No.1, 3 and 4. oxygen content: No4 > No.3 > No.1 (about 1000 ppm)

No.4 is a fast cooling sample

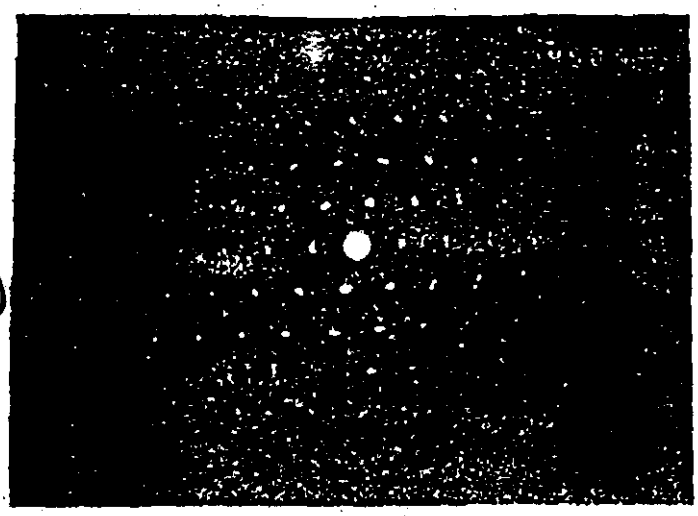
In powder form: ϕ 0.1 - 1 μm

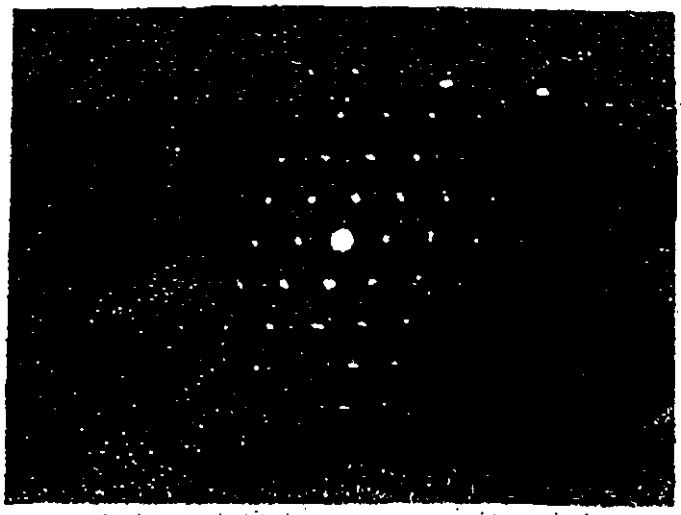
1. Observation of morphology change (Fig.9)

2. electron diffraction patterns (Fig.10)

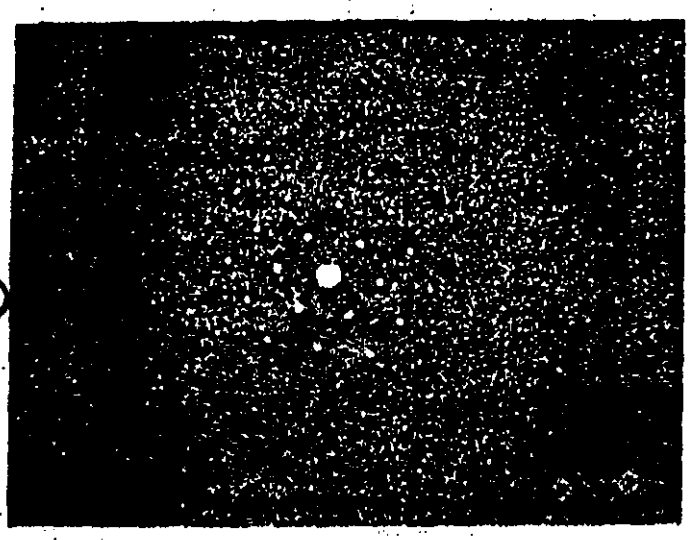
Transmission of samples after 10^6 rad irradiation (at 220 nm):

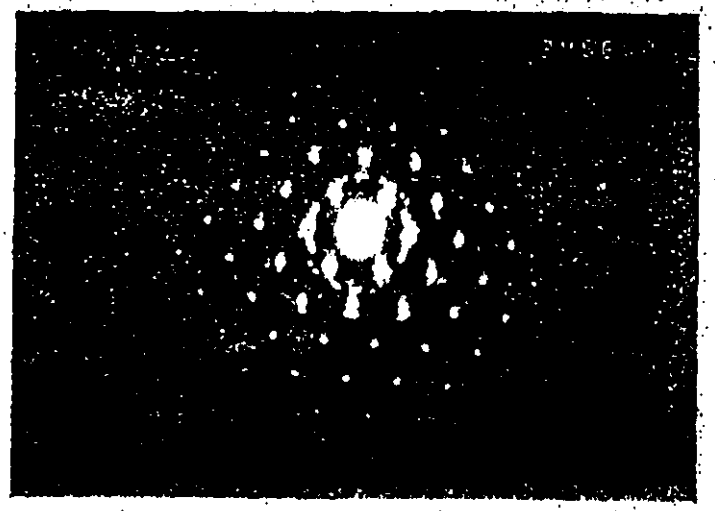
No.1: 50%, (25 cm long) No. 3: 25% No. 4: <5%





(1)





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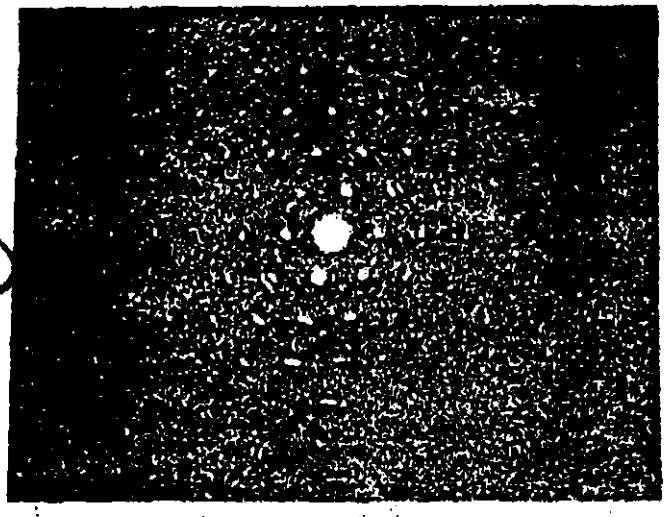
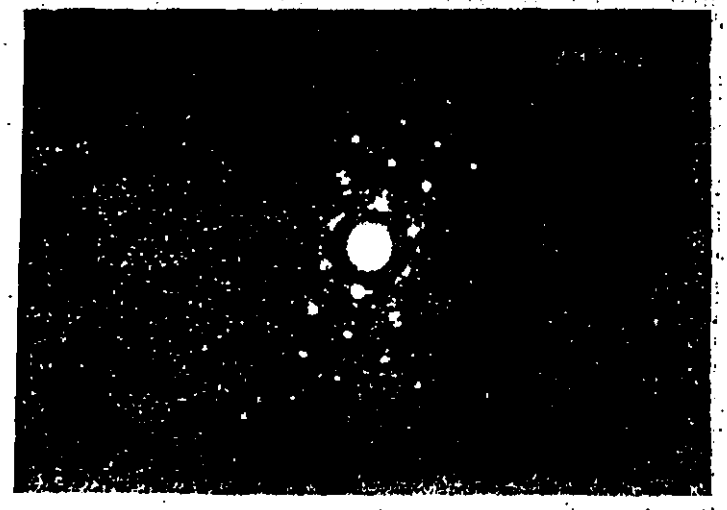
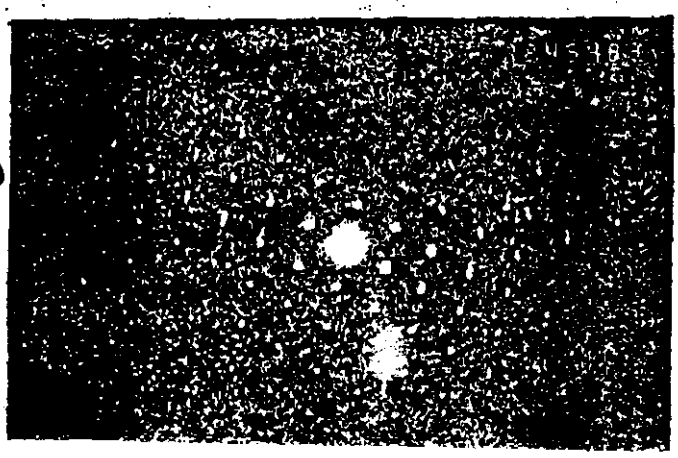




(4)



(4)'

Effect of OH^- on radiation damage in BaF_2

Pohl Institute of Solid State Physics, Tongji University

Sample: From Shanghai Institute of Ceramics

Heated in air (70% R.H) at 900°C

Hydrolysis Process:

$$BaF_2 + 2H_2O \longrightarrow Ba(OH)_2 + 2HF$$

OH^-: 192 nm

Radiolysis Process:

$$OH^- \longrightarrow \begin{cases} H_i^0 + O_s^- & \text{or} \\ H_s^- + O_i^0 \end{cases}$$

U: 204 nm ($U = H_s^-$)

793.75 cm^{-1}

O_s^-: ~ 240 nm

Calculation with Localized Spin-State Density-theory : Color Centers

Tab. 1 The absorption peaks of the color centres, hydroxyl and oxygen impurty centres

Color centres	λ (nm)	Color centres	λ (nm)	
F	611	O^{2-}	130	
			200	
M	720		290	
V_K	336	O^{2-}-V_a	123	148
	750		127	188
U	206	$F_H(O^{2-})$	394	
OH^-	191		443	
O^-	175	$F_{2H}(O^{2-})$	365	
	230		539	
	413			

From the above results we know the U,OH^-, O^- and O^{2-} centres would be all the possible sources for the damage in BaF_2, since they have the absorption bands near 220 nm. But we need to make it clear what would be the main one that results in the radiation damage in actual process.

3 Experimental Results and Discussion

3.1 Experimental Procedure

The BaF_2 crystals used in our experiment were provided by Shanghai Institute of Ceramics. One is 1# BaF_2 grown in recent experiment, and the other is 2# BaF_2 grown at low vacuum. All the samples were processed to the thickness of 2 mm. Some were treated in air above 900 °C. The characteristic of optical absorption curves of samples before and after γ -irradiation were obtained in the regions of VUV, UV and IR with Acton VM 505, Graphicord UV-204 and Nicolet DX-V 5.07 Spectrophotometres. The radiation test was performed with the dose of 1×10^6 rad.

Hydrolysis

#1: Good Crystal

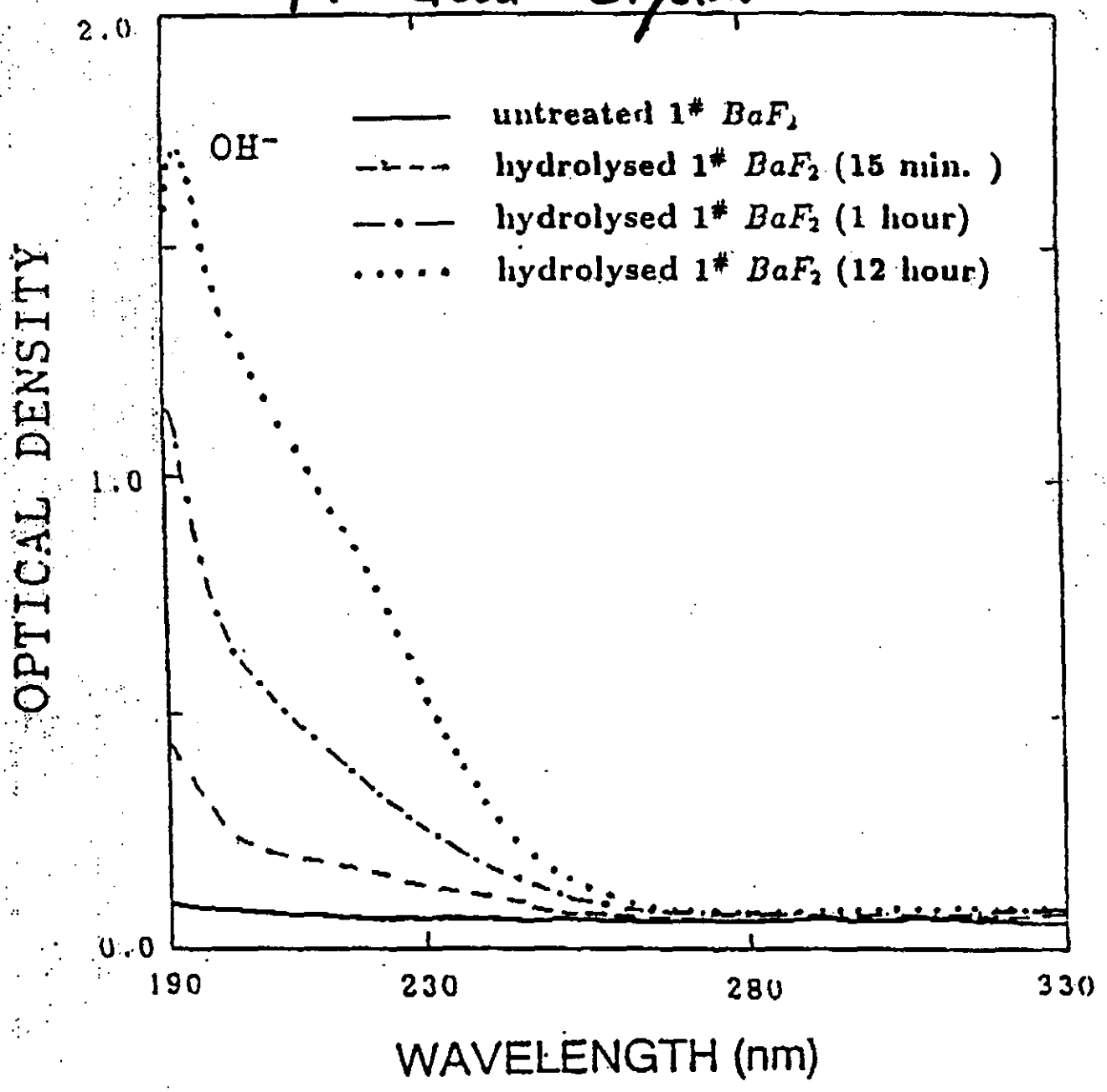


Fig. 1. Absorption spectra for different hydrolysed 1# BaF_2

#2: BaF_2 Crystal grown in low vacuum
OH^- contamination

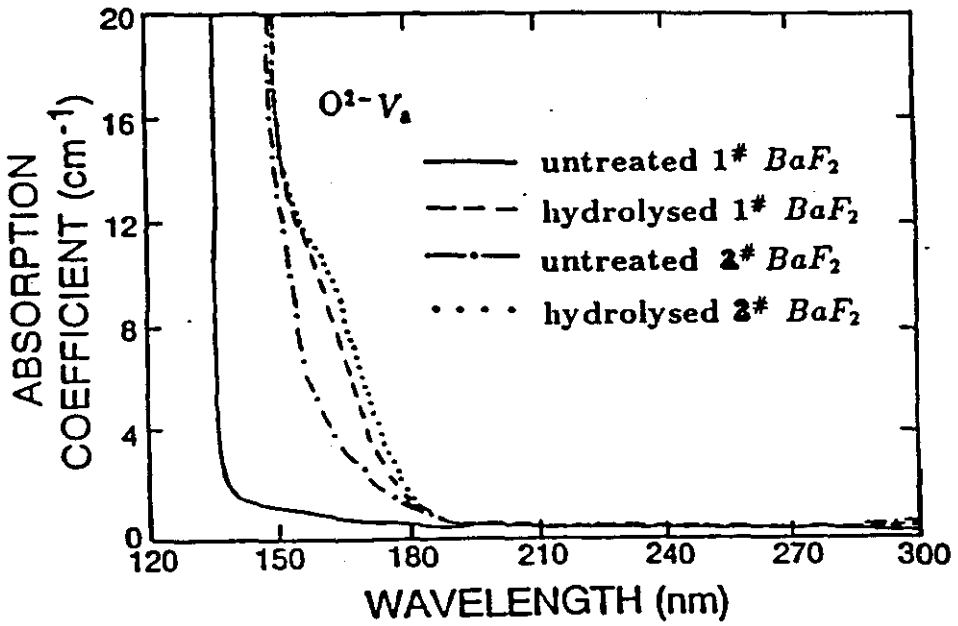


Fig. 3. VUV absorption for hydrolysed and untreated BaF_2

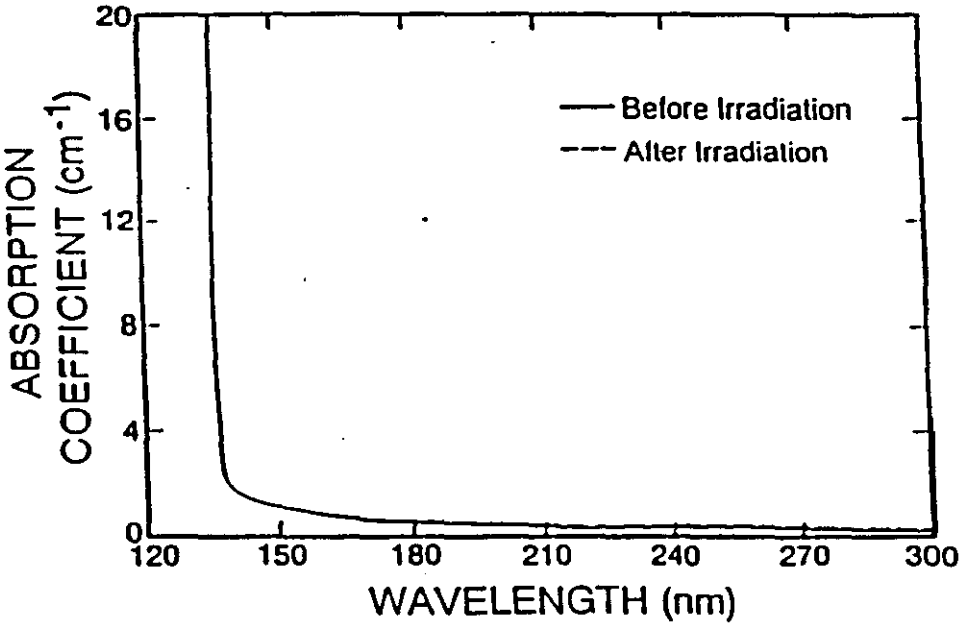


Fig. 4. Absorption spectra of 1# BaF_2 before and after irradiation

OH⁻ contaminated BaF_2 crystal
(#1 after hydrolysis)

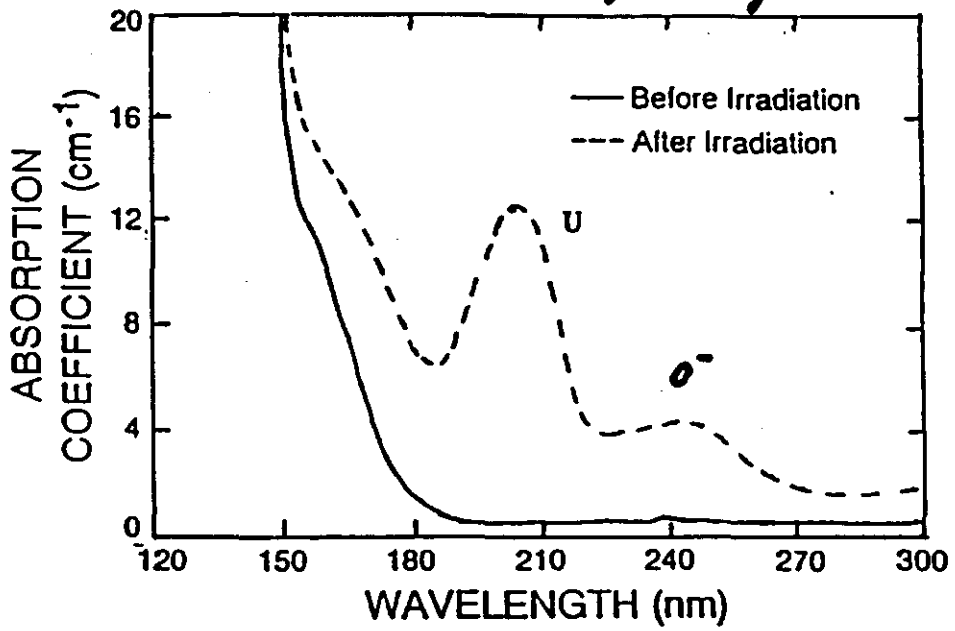


Fig. 5. Absorption spectra of hydrolysed 1# BaF_2 before and after irradiation

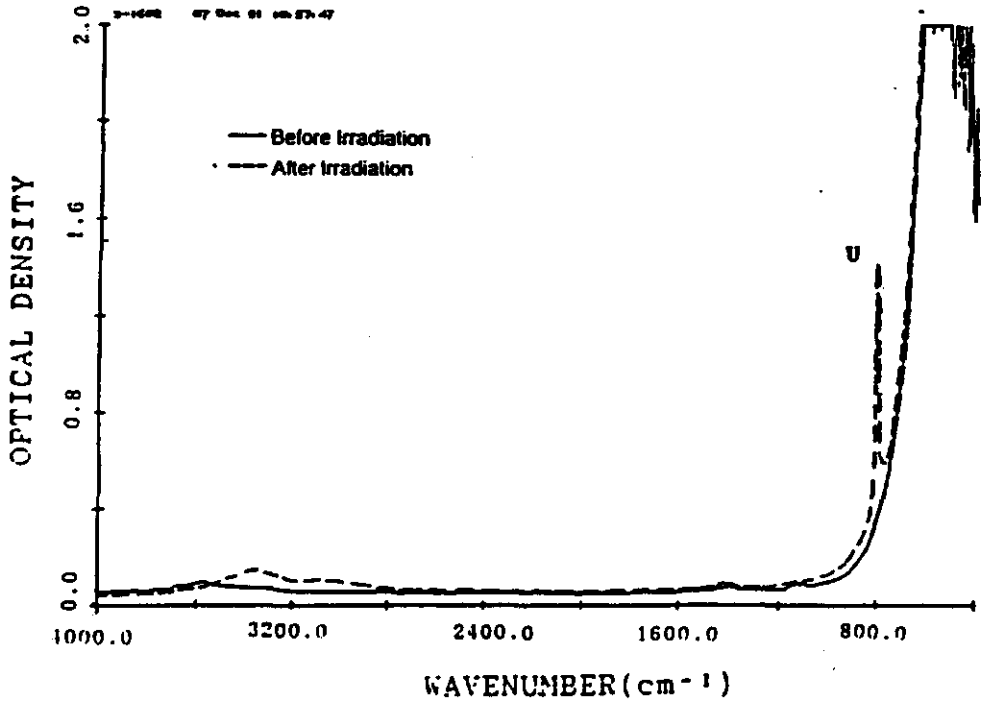


Fig. 6. IR Absorption spectra for hydrolysed 1# BaF_2 before and after irradiation

Crystal Production in China

BaF_2 EM CALORIMETER

1992 R&D PROGRAM

RADIATION HARD CRYSTAL PRODUCTION

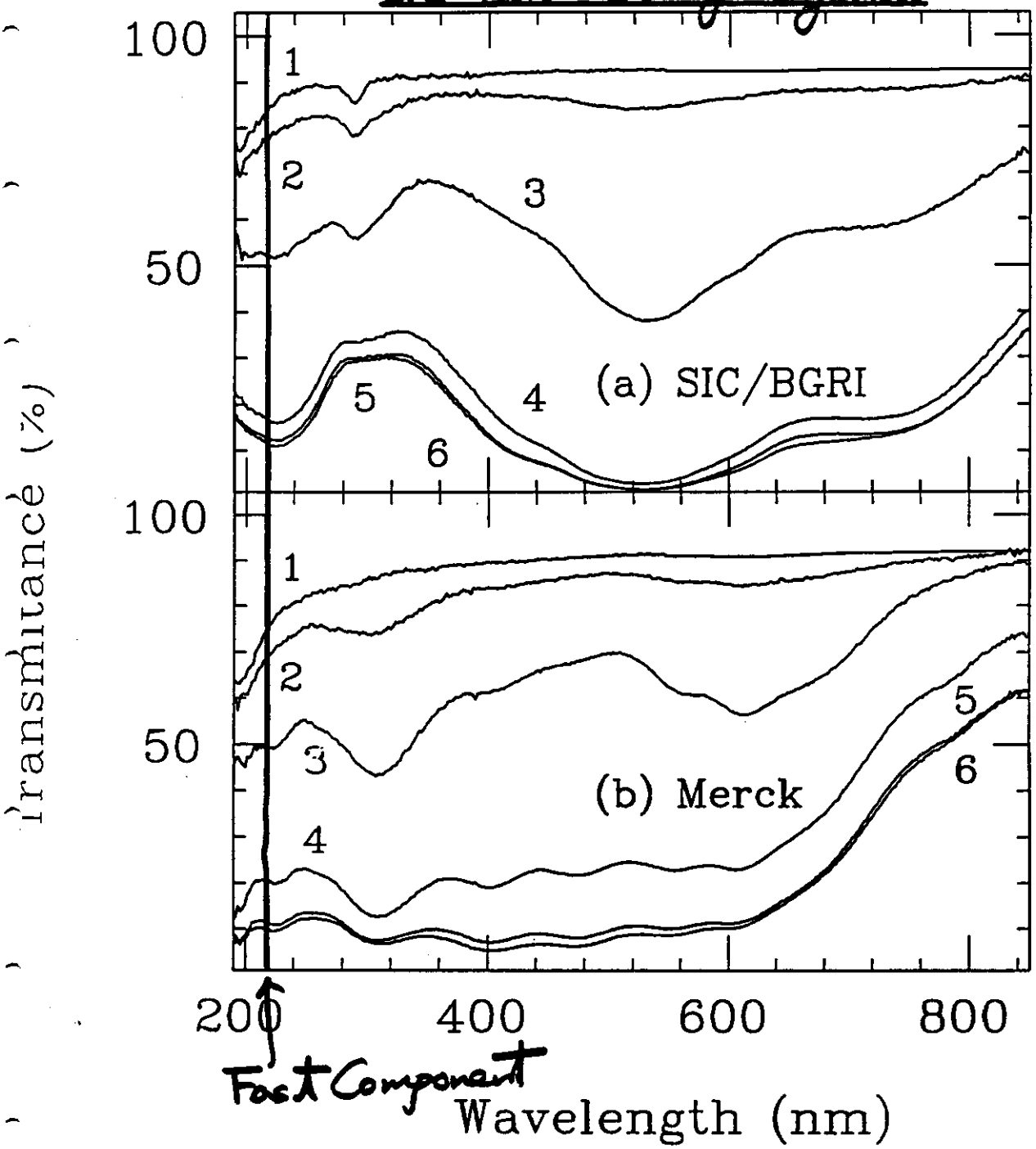
~50% @220nm
- 25 Full Sized Pairs With Improved Hardness Ordered (6/92) { Some boules are ready for mechanical process

60% @220nm
- 5 Full Sized Pairs Approaching Rad Hard Specs Ordered (7/92) { High vacuum Annealing

~70% @220 nm
- Large Rad-Hard Crystals Meeting Specs: Target Date End 92

Radiation Damage of BaF_2 (I)

2.5 Cm long Crystal



2: 100 Rads; 5. 100 kRads

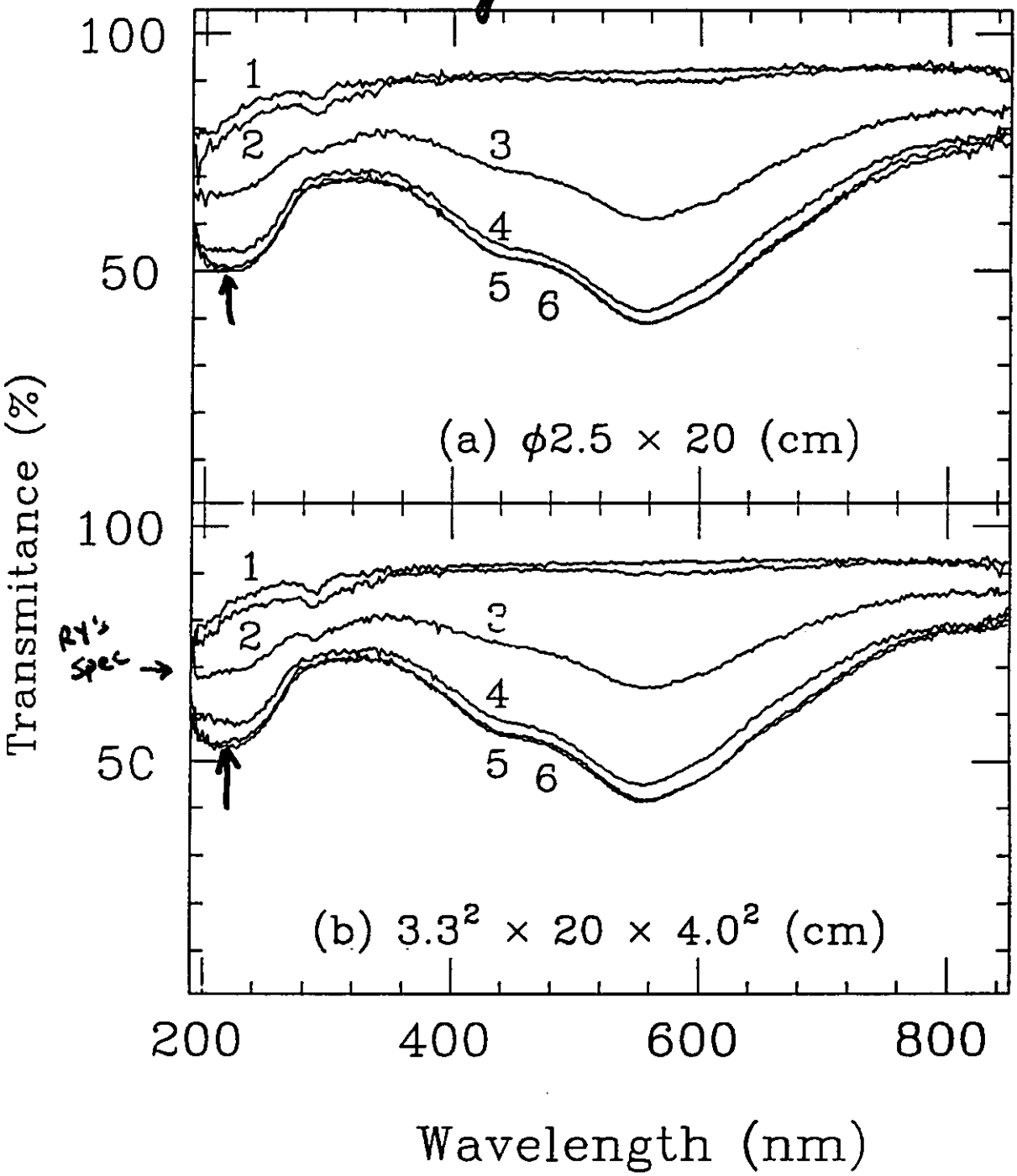
3: 1kRads; 6. 1 MRads.

4: 10kRads;

Dec. 1991

Radiation Damage of BaF_2 (II)

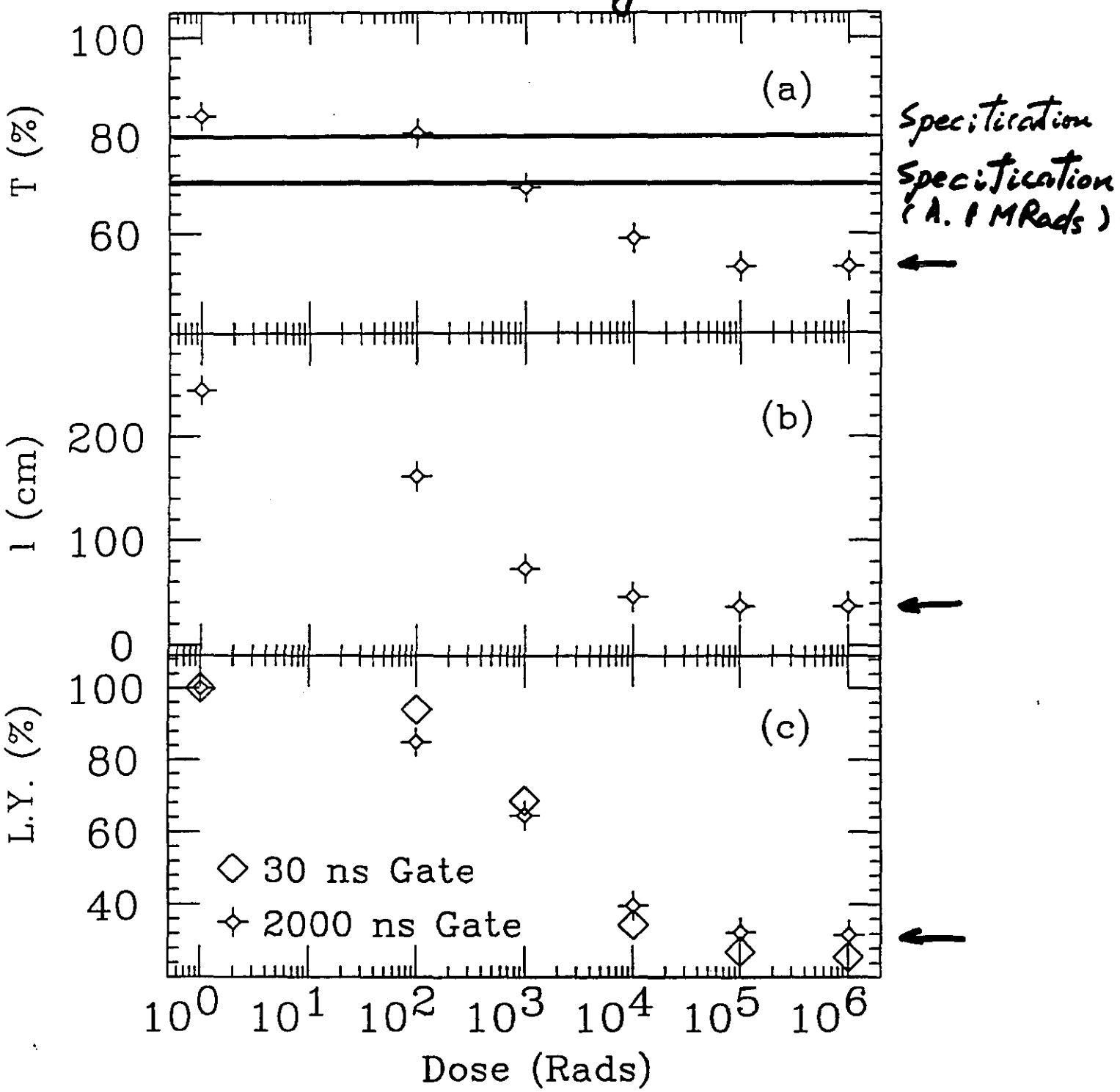
New Crystals from SIC 20 cm long



1: before irradiation;
2: 100 Rads;
3. 1 kRads;
4. 10 kRads;
5. 100 kRads;
6. 1 MRads.

Performance of New Chinese Crystal

20 cm long



Saturation in both transmittance & light yield.

A 25 cm long BaF_2 Crystal

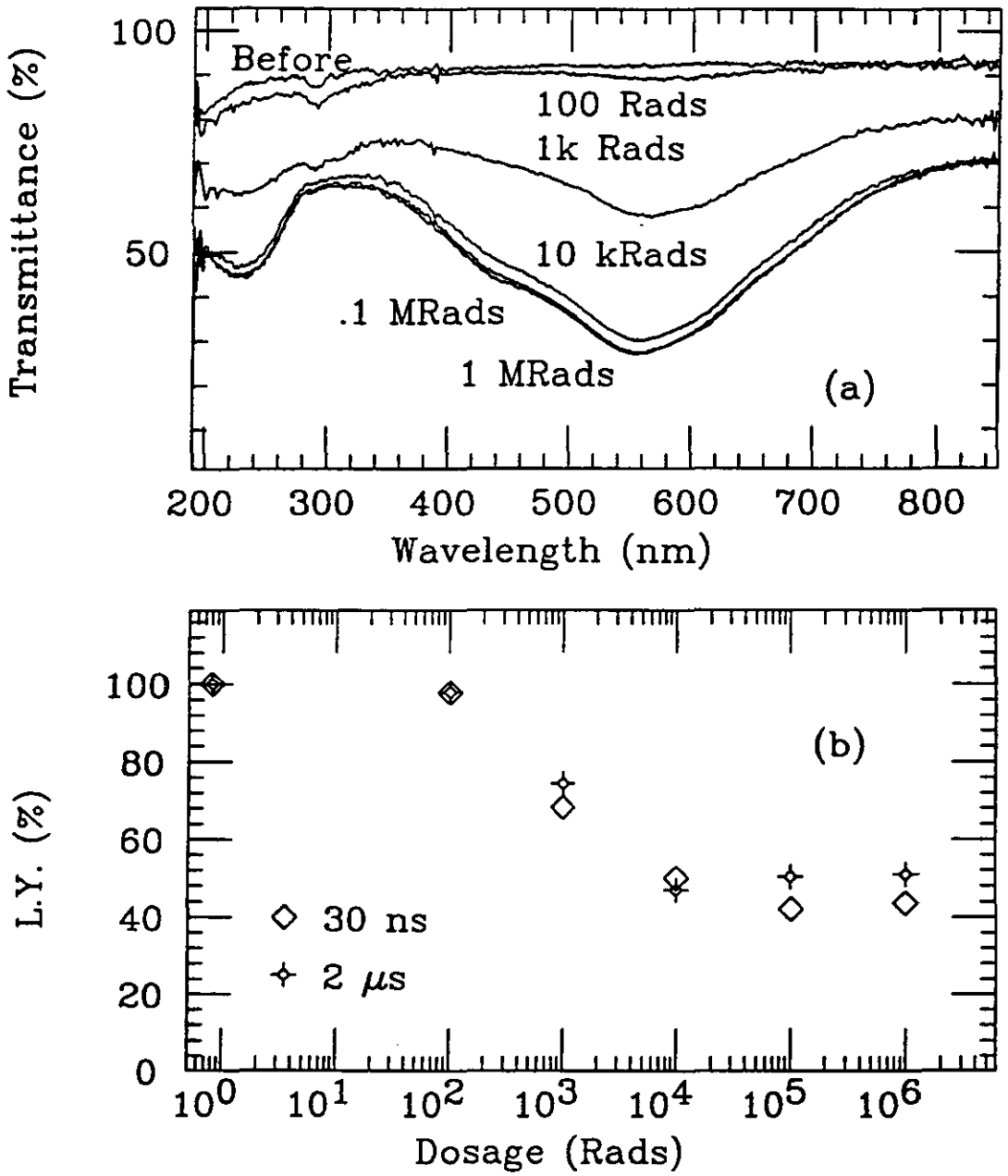


Figure 6: Transmittance (a) and relative light yield (b) measured with a 25 cm long BaF_2 crystal are shown as function of dosage.

Tsinghua/China

MEMORANDUM OF UNDERSTANDING

BETWEEN

THE GEM COLLABORATION
SSC U.S.A.

AND

TSINGHUA UNIVERSITY
BEIJING, CHINA

A PROGRAM OF COLLABORATION ON THE GEM PROJECT OF SSC

MAY 23, 1992

The objective of this memorandum is to establish an arrangement that Tsinghua University can most effectively perform collaboration on the GEM project of the Superconducting Super Collider (SSC).

Main collaboration mechanism is summarised below.

1. Tsinghua University will join the GEM collaboration and make contributions,which particularly toward building GEM, as well as operating experiment and producing physics results.

2. Tsinghua University Nuclear Instrumentation Center (TUNIC) will take the responsibility of this collaboration . The following departments are selected to be the participants at the first stage.

Dept. of Engineering Physics	Electronics and detector modules
Dept. of Applied Physics	Detector and experiments
Institute of Nuclear Energy	Gas detectors
Institute of Micro-electronics	Custom chips
Dept. of Mechanical Engineering	Laser welding and Mechanical structure
Dept. of Precision Instruments	Fine processing of optical crystals, Optical alignment
Dept. of Thermal Engineering	Thermal control and cooling system

3. Selected professors,engineers,postdoctors and technicians of

Tsinghua University will work on GEM project for SSC. The devices and material which should be purchased on the international market will be offered by SSC. The technical specifications, time schedule and total budget of a subproject of this collaboration will be signed case by case.

4. GEM will offer the complete R&D documents for prototype making and testing. SSC will support the visiting scholar or engineer of Tsinghua University to join R&D in USA before and after a contract of the related subproject has been signed.

5. Listed below are the most possible subprojects of GEM-Tsinghua collaboration.

- Fine processing of BaF_2 crystals
- Titanium cover for BaF_2 crystal
- Prototype of electronics circuit board,mass production and testing for EM calorimeter,hardron calorimeter and Muon chamber.
- BaF_2 / LAr detector assembling and testing.
- Custom chips (Preamp, shaping amp, analog and digital pipeline ,ADC, etc.)
- Composite structures.
- Absorber plate for H-calorimeter and Muon chamber
- Thermal control system.
- Optical alignment of GEM detector.

Agreed

William Willis
Spokesman of GEM
collaboration
Date: 24 May 1992

(Ni Wei-dou)
Ni Wei-Dou
Vice-president of
Tsinghua University
Date: 24 May, 1992

USTC / China

To : Prof. W.Willis (GEM Spokesman)

From : Asso. Prof. BingXin Yang, Department of Modern Physics,
University of Science and Technology of China, Hefei
230026, P.R. China, FAX : 86-551-331760

The GEM group at USTC would like to contribute to the following area of GEM Physics program :

A. EM calorimeter -- BAF2 option;
   1. Radiation damage study of BAF2;
   2. BAF2 crystals quality control;
   3. Cosmic ray test;
   4. Assembly.

B. Detector and physics simulation and data analysis.

C. Electronics and DAQ.

The GEM group at USTC consists of the following members :

A : Department of modern Phsics
   2 Prof., 6 Asso. Prof., 7 Lectures, 4 Asis. Prof.;

B : Centre Laboratory of Structure and Element Analysis :
   5 Asso. prof.

To perform physics simulation we need two workstations from GEM which will be used at USTC to permorm GEM relateve simulation task and educate students. One physist of the USTC will visit SSCL in near future to receive the workstations.

殷之文先生转朱人元先生收.

IHEP/china

MEMORANDUM of MUTUAL UDERSTANDING

between

The GEM Collaboration

SSC, U.S.A.

and

The institute of high energy Physics Beijing, China

A program of collaboration on the GEM experiment at the SSC in the design and construction phase

May 24, 1992

The spokesman of GEM experiment, Prof. W. Willis and other members attended the Beijing GEM meeting on May 20th at IHEP and the First East Asia/Pacific-US Symposium on SSC physics, Experiments and Technology from May 21 to 24 held at CCAST,Beijing. During these meetings, extensive discussion with the director of IHEP, S.X. Fang, the deputy director of IHEP, Z.P.Zheng, and the member of the IHEP GEM group were carried out to idendify the role of IHEP's participation in GEM experiment during design and construction phase.

The spokesman of GEM collaboration noticed that a IHEP GEM group has been established and is working actively to explore the possible area of GEM experiment where they can make contribution.

IHEP appreciates highly the expectation of GEM experiment that IHEP can take leading role in calorimeter system. According to present ecnomical condition of China, IHEP could only contribute their experience, manpower and help to reduce the the construction cost to meet partialy the budget need of GEM as the contribution to SSC project.

IHEP expressed its intention of participating GEM experiment during design and construction phase. In following four items where IHEP could contribute. GEM management will provide necessary assistance to help IHEP's participatian in GEM experiment.

A. BaF2 EM calorimeter

As the tasks of BaF2 EM calorimeter have been assigned to many institutions of China, IHEP would like explicitly join the cosmic ray test as well as assembling of BaF2 detector. Detailed specifications are requested and cost estimate will be made later.

B. Liquid Argon Calorimeter

IHEP intends to undertake the production of absorber plates and electrodes, participate quality control (and module construction). If the LAr option is selected, IHEP GEM group would be involved further.

GEM collaboration would invite one physicist from IHEP and one engineer from Shanghai Aircraft factory to join the 1mm option beam test starting late Jun. for final decision of Calorimeter options in August. After that they will join the design of LAr calorimeter or scintillation fiber hadronic calorimeter according to the final calorimeter selection.Their expenditure will be provided by GEM collaboration.

C. Scintillation Fiber Hadronic Calorimeter

IHEP intends to join the design of scintillation fiber hadronic calorimeter and be in charge of mechanical processing, assembling, quality control and detector characteristics test.

D. Muon System

As the technique of the muon system has not been determined, IHEP only expresses its intention of participating R & D of mass production and undertake part of the mass production of any chosen option for muon system.

Members of GEM collaboration visited the facilities for muon detector manu facturing in IHEP and had a deep impression on it. Part of muon system mass production will be assigned to IHEP GEM group. GEM collaboration would invite one physicist and one engineer to visit U.S. in July for six weeks, they will investigate diffrent techniques for muon detector and participate in designing later on. GEM collaboration will provide the expenditure.

In the design phase, IHEP would participate GEM muon detector simulation. workstations are requested from SSC GEM collaboration for doing the simulation at IHEP. Network support is also needed for intensive discusstion and software upgrade in simulation.

As the first step, GEM collaboration would provide two workstations to IHEP and one physicist is invited to U.S for about one month to learn the simulation software and accept the workstations. GEM collaboration will provide the expenditure.

Agreed

William Willis, spokesman of	Fang Shou-xian, Director of
GEM collaboration	Institute of High Energy Physics
Date:	Date:

Interest of Chinese Collaborators

- BaF_2 Calorimeter:
  - BaF_2 Crystal Production: SIC/BGRI;
  - Crystal Quality Control & Cosmic Test: IHEP/USTC;
  - Mechanical Support Structure: Tsinghua;
  - Detector Assembly: IHEP/USTC/Tsinghua;
  - Thermal Control System: Tsinghua.
- L Ar Calorimeter & SHCAL:
  - Design & Absorber Processing: IHEP/Tsinghua.
- Muon Chamber:
  - Mass Production (1/4 of Barrel): IHEP/Tsinghua.
- Electronics for all Subsystems:
  - A Joint Center: Tsinghua/IHEP/USTC.

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Presentation by:

F. Taylor

June 4, 1992
Frank E. Taylor

Status of Muon System

Recent activities:

Engineering:

(a) Strengthened group:

Howie Baker - Draper Project Management
Joe Pohlen - MM System Integration
Jacques Pier-Amory - SSCL Installation & Integration
Funding for alignment task:
Joe Paradiso - Draper Muon system
Rick Sawicki - LLNL Global Alignment

(b) Design:

Attachment of support structure to magnet

Computation of solid angle coverage with real chambers

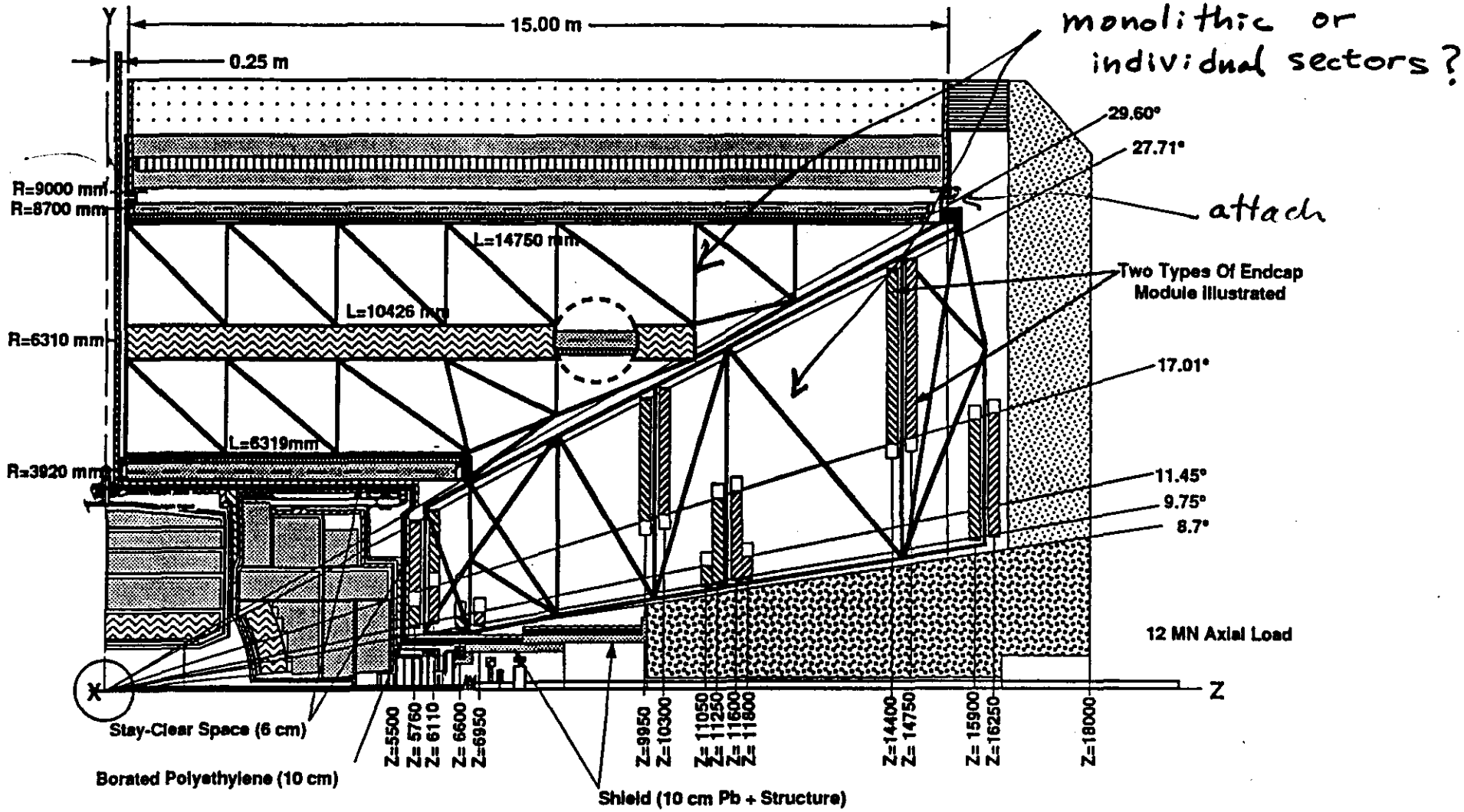
Package for July PAC

(c) Installation of sectors in magnet:

Options:

Monolithic structure assembled outside

Individual sectors installed one-by-one



GEM MUON SYSTEM (BASELINE)

(4/8/4 layers for Theta = 9.75° to 11.45°)
With Baseline LAr Calorimeter Illustrated

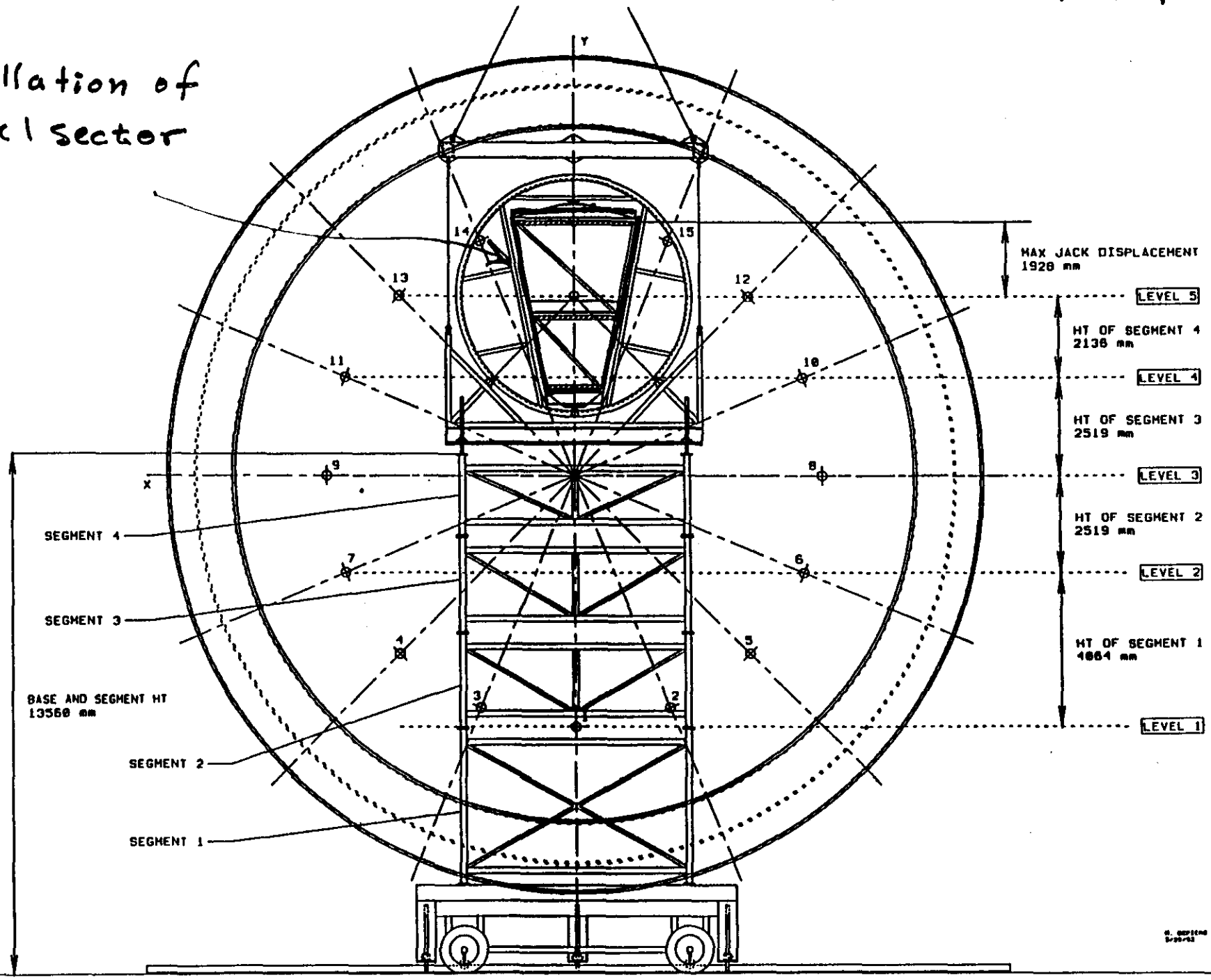
Details of interface with the endcap muon system and the beampipe shield with the Forward Calorimeter remain unresolved

Draper Laboratory		
GEM Muon System (BASELINE) (LAr Calorimeter)		
Drawn By:	F. Nimblett	Rev (-)
Dwg. No:	GMU0012	3/27/92
Approved by:		

new to attach to magnet - field lines

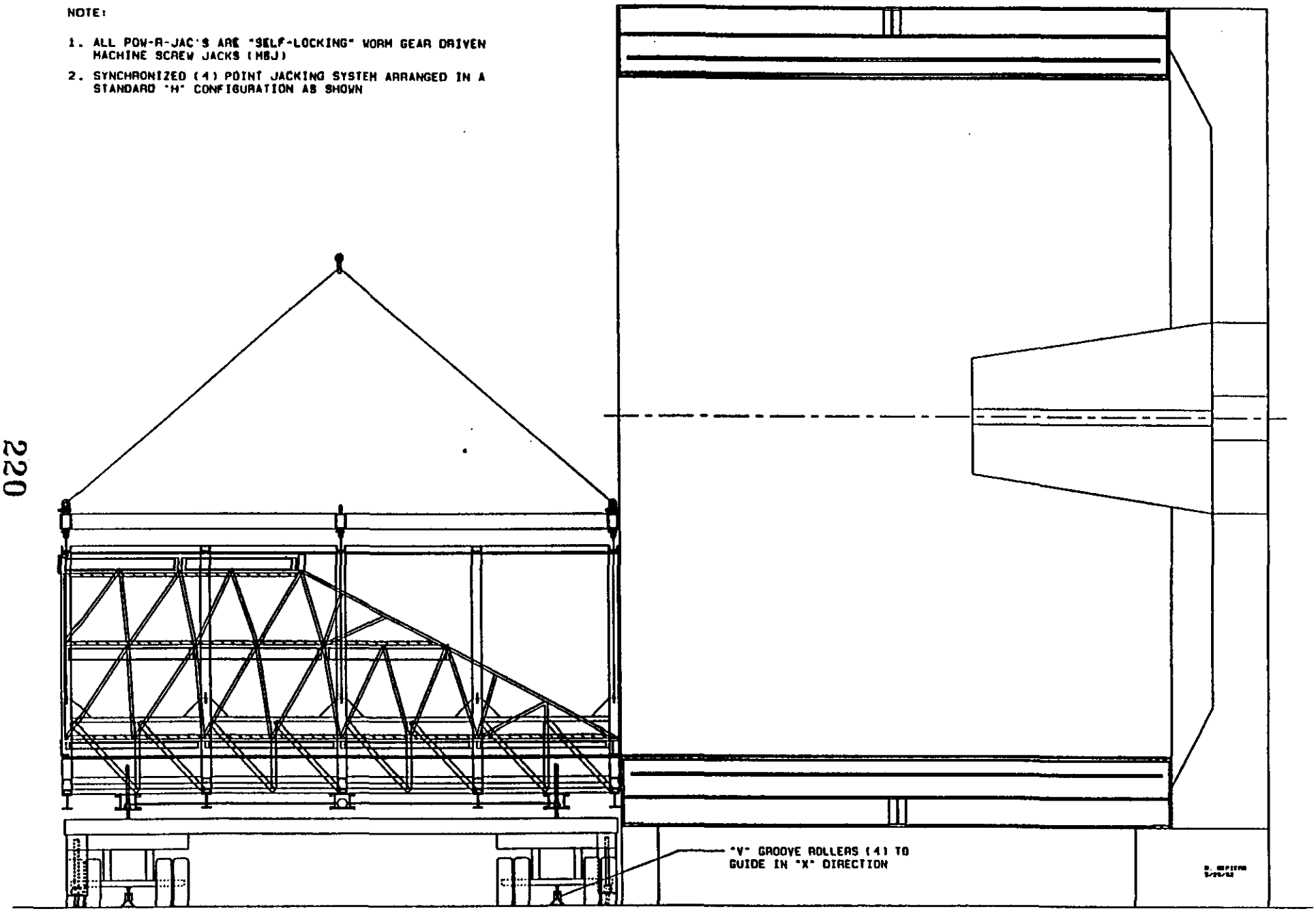
M. DePiero/Draper

installation of barrel sector



NOTE:

1. ALL POW-R-JAC'S ARE "SELF-LOCKING" WORM GEAR DRIVEN MACHINE SCREW JACKS (MSJ)
2. SYNCHRONIZED (4) POINT JACKING SYSTEM ARRANGED IN A STANDARD "H" CONFIGURATION AS SHOWN



Cost Review: May 5

			with electronics
(a)	Barrel: PDT with RPC trigger Endcap CSC	------	$ 129 M
(b)	Barrel:LSDT with RPC trigger Endcap CSC	------	$ 121 M

			without electronics
(c)	Barrel: PDT with RPC trigger Endcap CSC	------	$ 95 M
(d)	Barrel:LSDT with RPC trigger Endcap CSC	------	$ 89 M

How to descope?

Action items being worked on.

Pattern Recognition Software Meeting BNL: May 19

Organize the muon hit-level Monte Carlo Efforts

Goals:

- Generate fake events and reconstruct

- Include backgrounds - muon associated, punch-through, neutrons

- Evaluate system performance with bkgs and inefficiencies

- Study pattern recognition / technology / heavy quarks

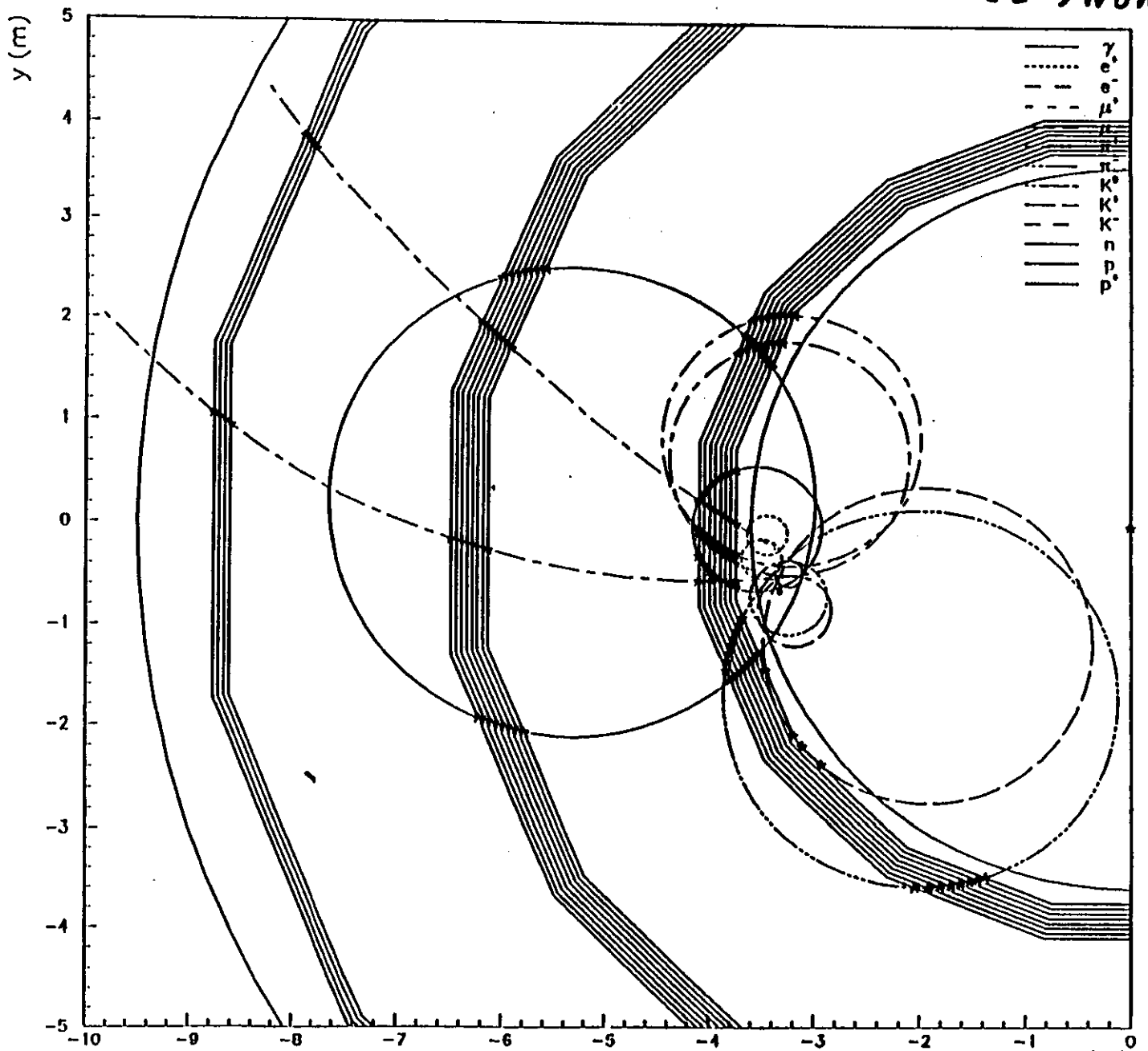
Hit Level M.C.

GEM Data Plot

Chiaki Yanagisawa

μ^-

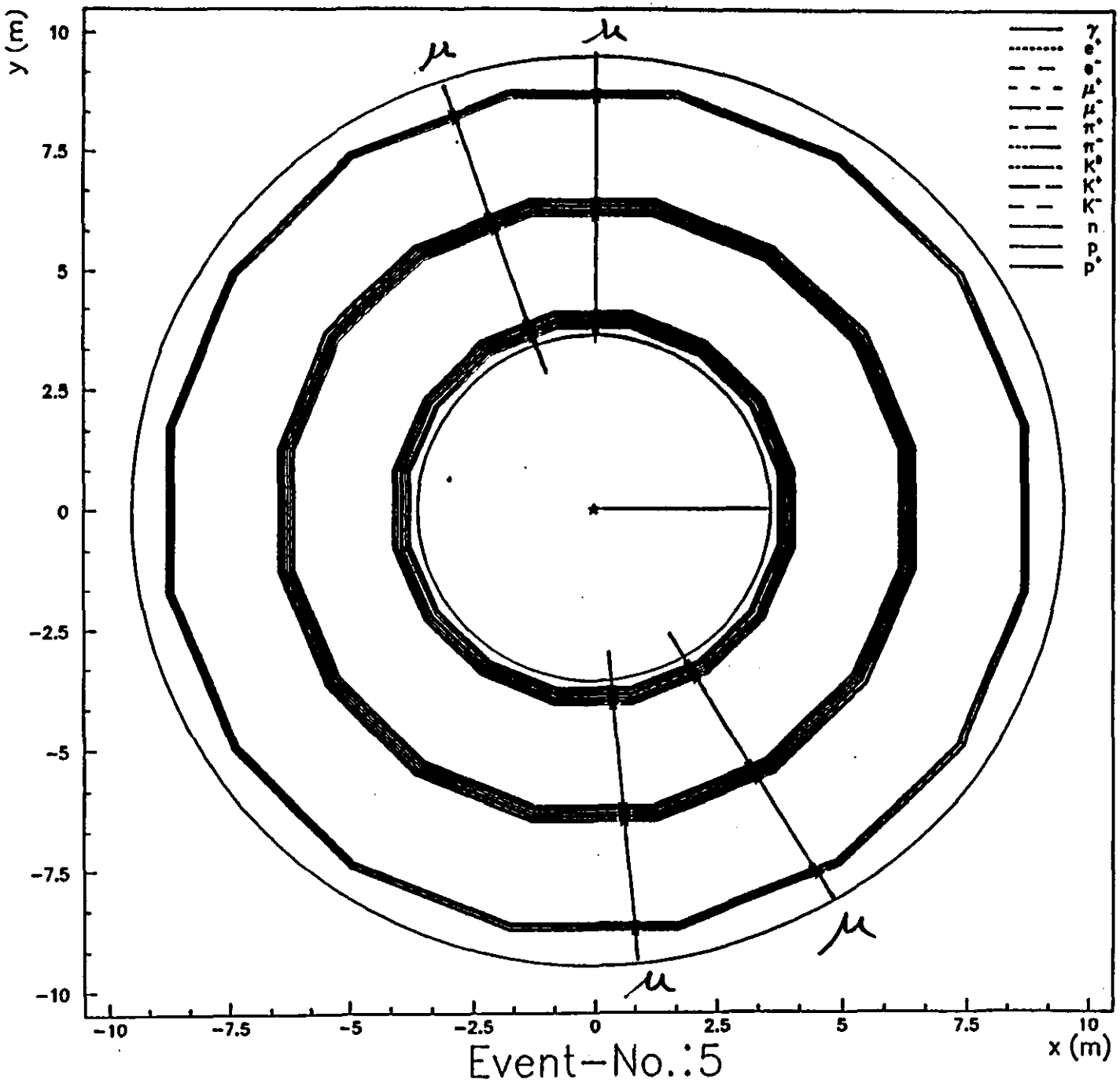
$t\bar{t} \to WbWb$



Event–No.: 133

GEM Data Plot

Higgs→ZZ→4μ



Event-No.:5

Roger McNeil

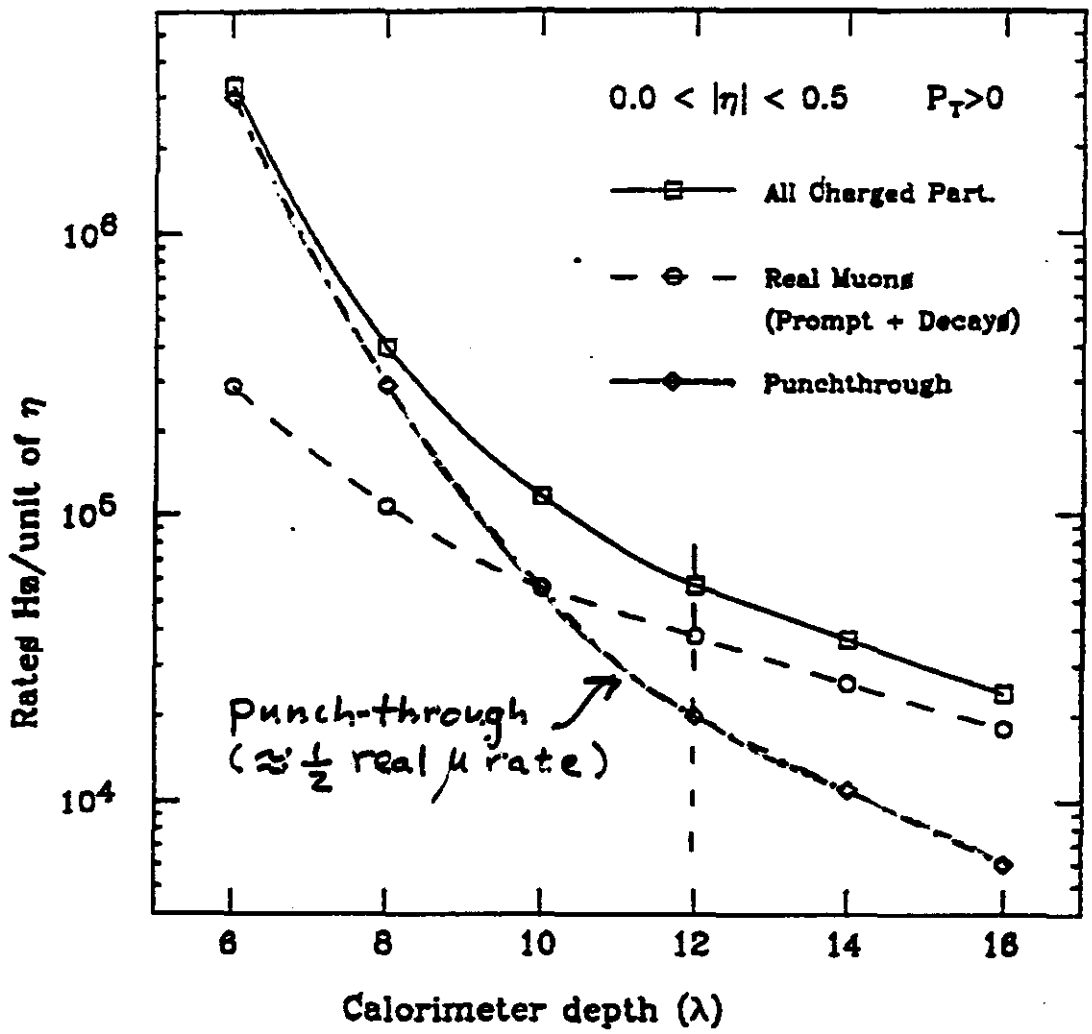


Figure 10.3-1a

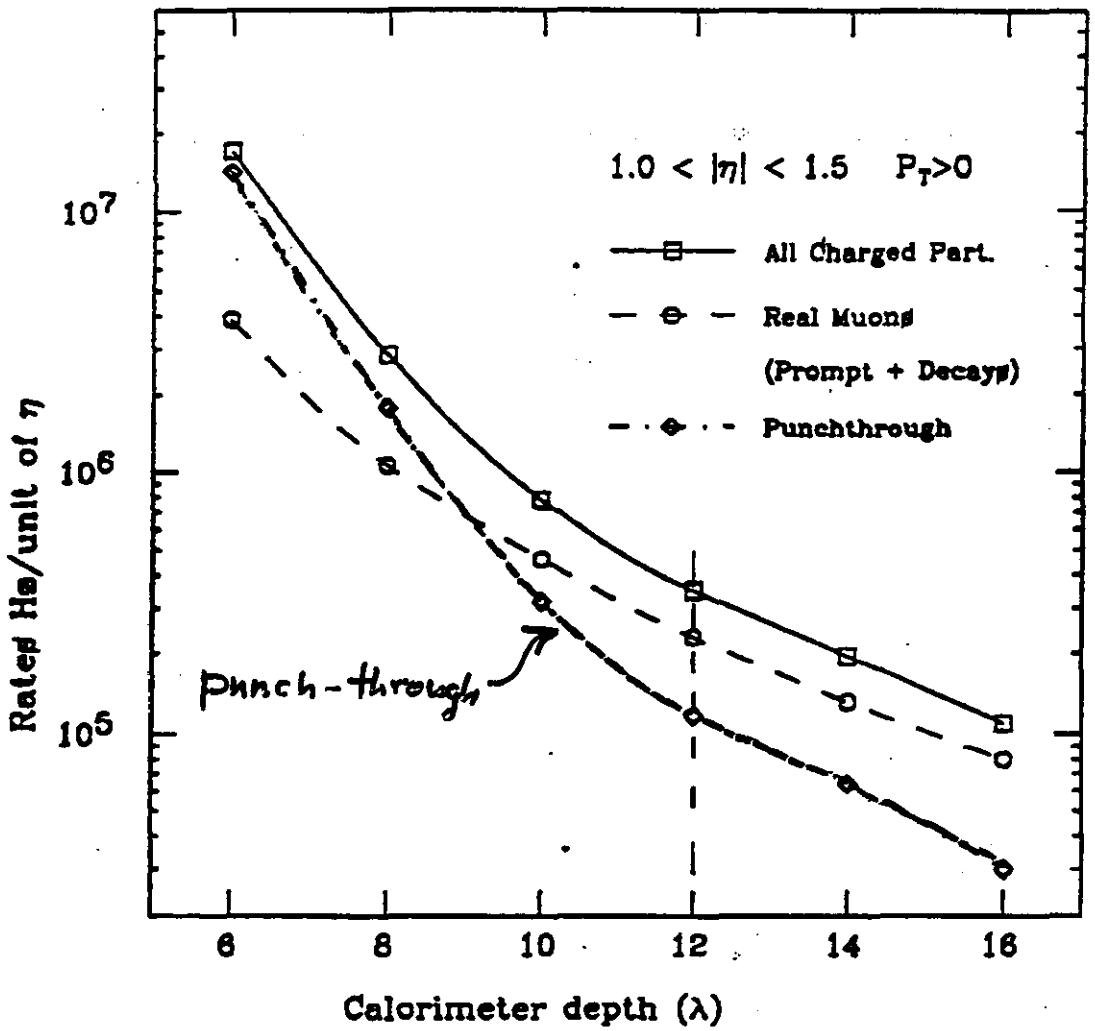


Figure 10.3-1b

Alignment Meeting-SSCL May 22

Organize efforts for muon system & integrate in GEM

- Detail specifications for each dimension of system

- Review of straightness monitor technologies
  - LED-Lens
  - SWAT - stretched wire
  - LASER beacon

- Transfer technologies to chamber proponents

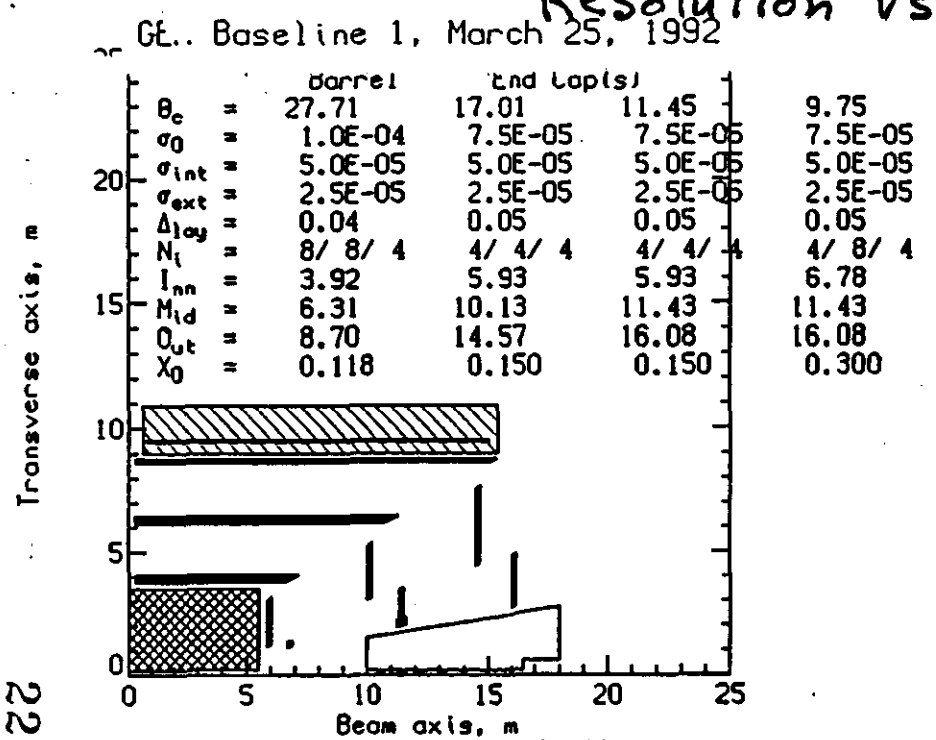
- Compile table of straight-line monitor options

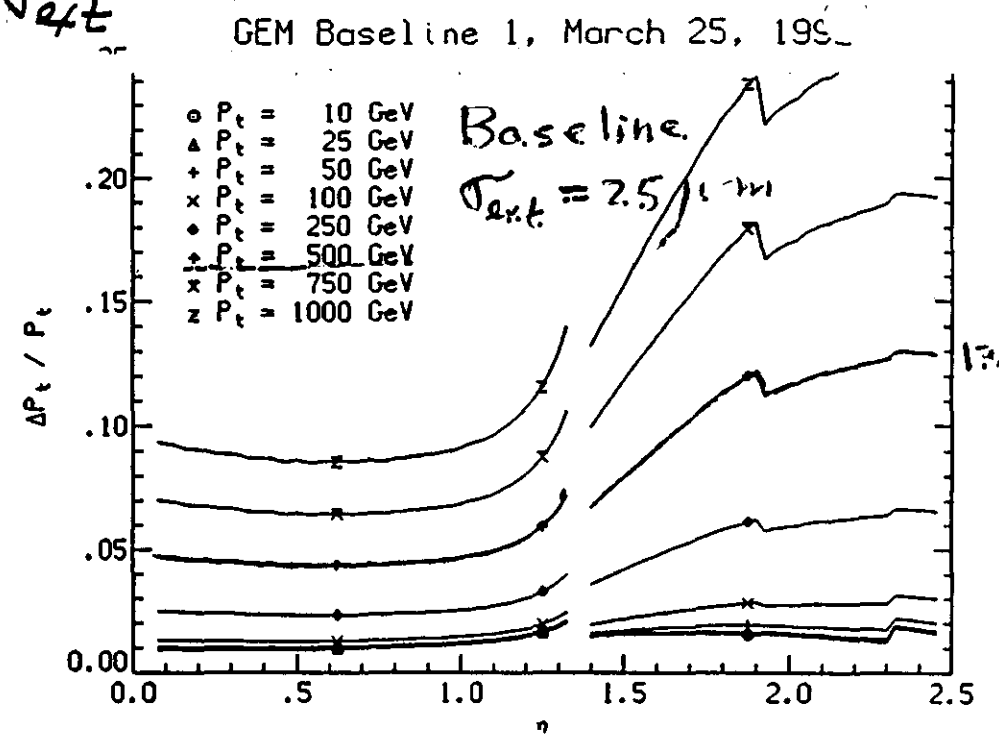
- Integrate requirements into support structure

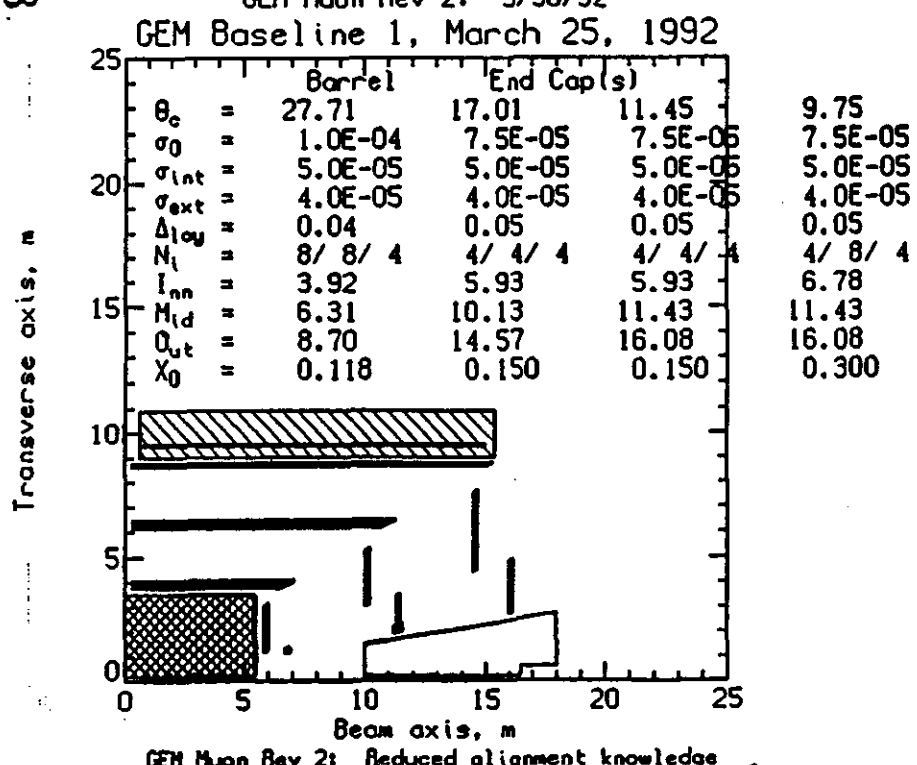
- Each technology tabulate their own error budget

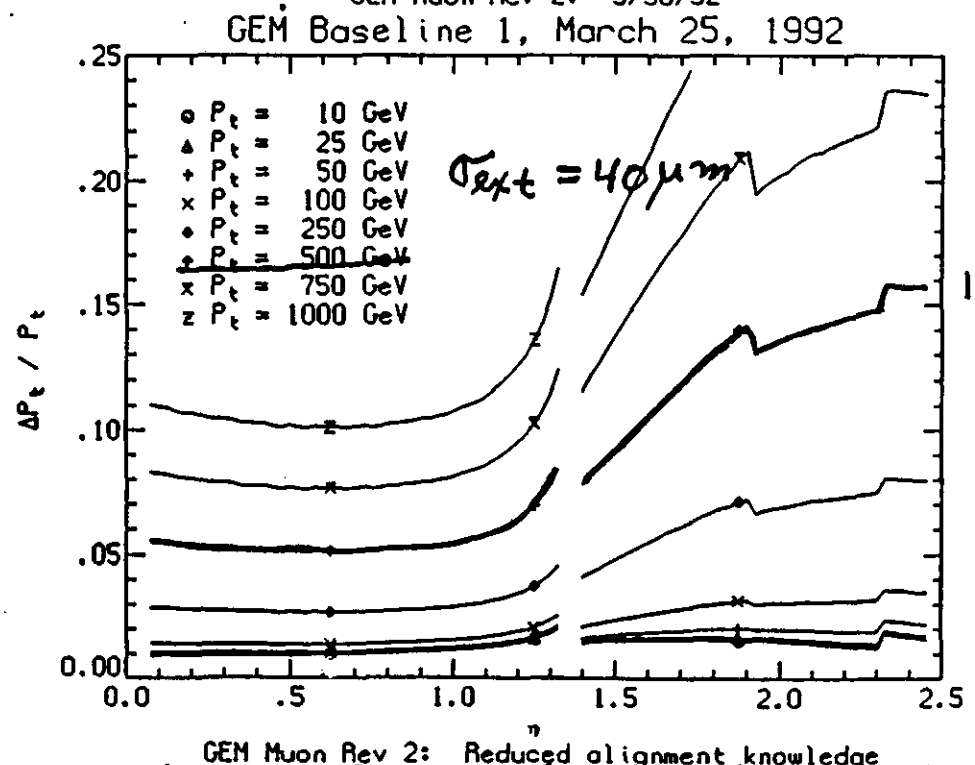
[Meet again June 10, 1992 at Draper]

Resolution Vs σ_{ext}









Joe Paradiso / Draper

L3 Requirements Analysis (analogy)

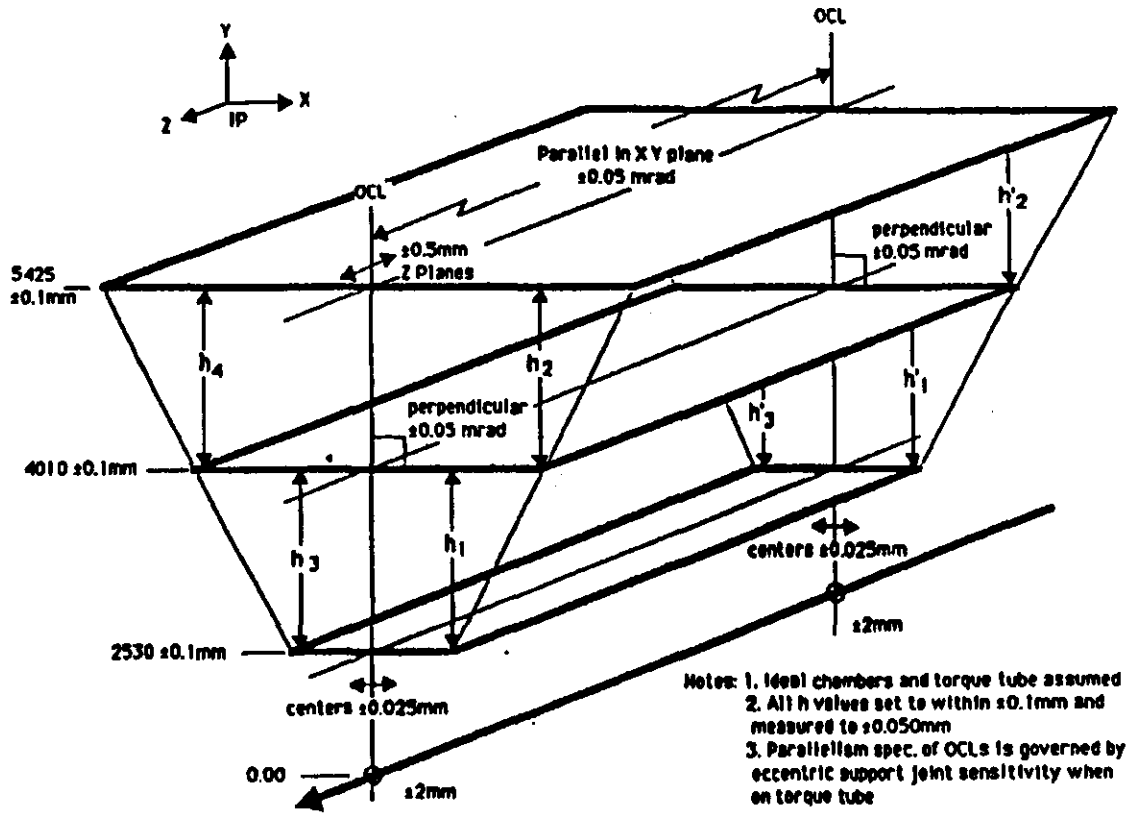


Figure 1-5. Octant array alignment tolerances: prototype design goal limits.

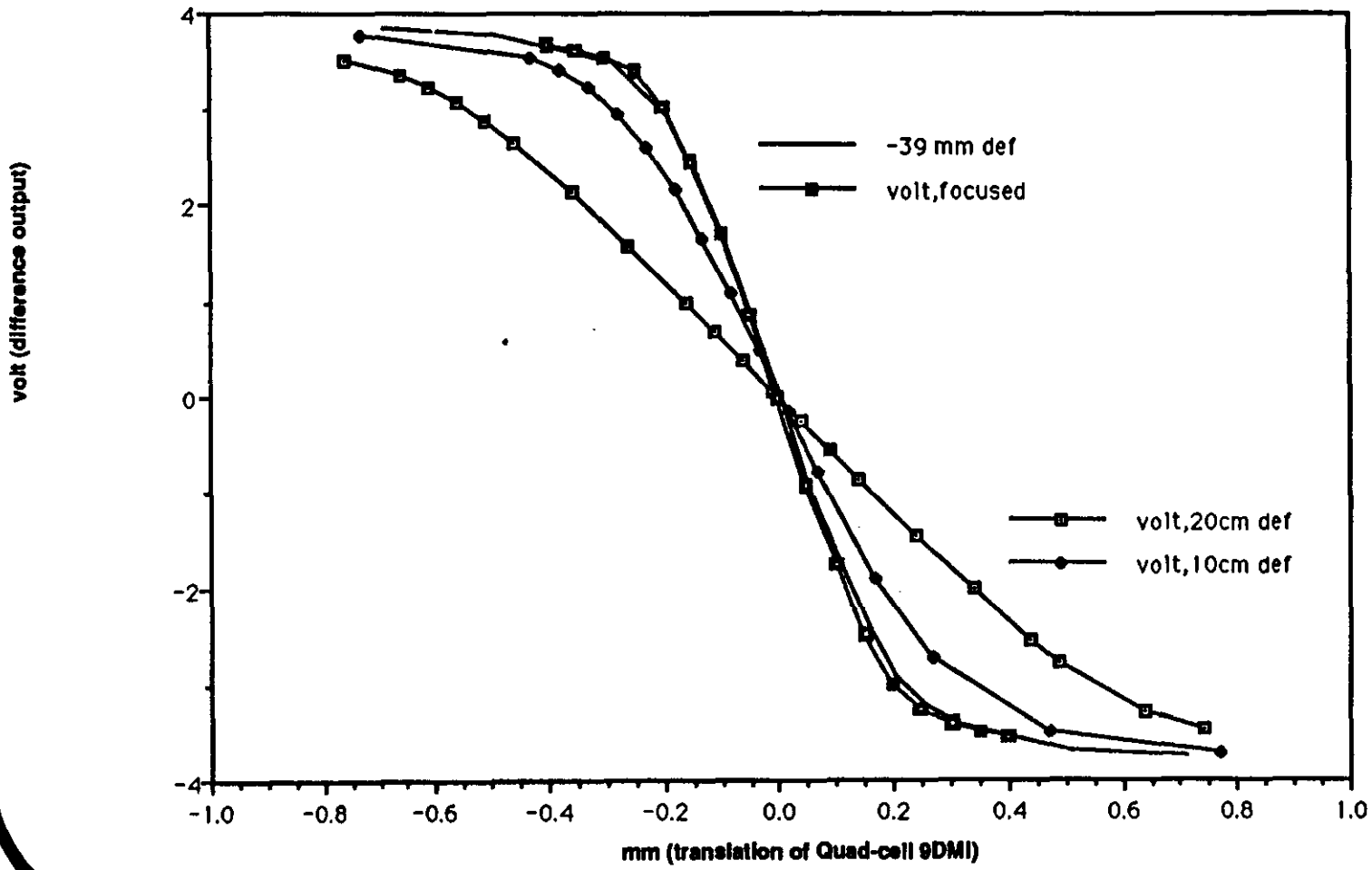
→ Need for GEM barrel, endcaps!

229

Straightness Monitor Resolution

Linear range can be extended by defocusing:
Comparison 0, .4, 10, 20 cm defocus (LED 1102, ambient light on)

(9 meter path)



Chamber Technologies

(a) Neutron tests at MIT:

CSC, LSDT, and RPC exposed to C_f neutron source.
Sensitivity to neutrons measured.
Results being analyzed.

(b) Full-scale chamber prototypes at TTR

Plan to ship them this August.

(c) CSC at RD5/CERN early fall

Proposal funded through TNRLC.

(d) How to choose chamber technology for TDR:

Resolution, alignment, cost, robustness....
Memo written and will be discussed with Muon Steering Committee and Muon Group.

June 2,1992

D R A F T - III

TO: GEM Muon Group
FROM: Muon Group Steering Committee
SUBJECT: Which Technology(ies) ?

The following is a list of the criteria which will be used to judge which technology we will take for the Engineering Design Report. It is hoped that these decisions be made in the time scale of early fall - 1992.

Sources of Information:

Calculations:
These can be used to evaluate the influence of various sources of error and should be presented with sufficient detail in order to judge their accuracy. Important assumptions should be clearly stated.

Texas Test Rig:
It is anticipated that cosmic rays, with the hardened momentum spectrum possible at the TTR, will be used to determine the single layer resolution of the proposed tracking technologies. Tests will also be performed on the TTR to investigate the compatability with other technologies (if relevant). Some measures of the robustness of the technologies can also be obtained. These will involve noise susceptibility, sensitivity to ambient temperature, and pressure.

RD5 tests at CERN:
This series of tests should determine the single layer resolution of the CSC option using beam muons. Measurements of the associated delta rays, pile up should also be possible. The rate of hadron punch-through should also be measured.

Muon beam tests at FNAL:
Data have been taken with the LSDT chambers in a 0.5 TeV/c muon beam. These results determined the layer resolution (B=0) and the delta ray flux from absorber in front of the detector. There is a possibility to run again at FNAL during the summer of '93 (between collider runs) using the E665 magnet and muon beam.

Neutron source tests:
Tests have been performed using a Cf neutron source at MIT. The RPCs, LSDTs, and CSCs were exposed to the source. The efficiency for detecting neutrons in each technology will be determined from these data. Further tests may be necessary to explore the sensitivity to gas mixture, chamber construction.

For Momentum Determination:

(I) Performance - Spatial:

(1) Layer Resolution: < 100 microns for barrel region (random)
< 75 microns for endcap region (random)

Barrel option with Cathode Strip Chamber

maged Atiya
Dan Marlow

Hexcel chambers with cathodes along the z-direction. Effective cathode segmentation is 5mm. Wire spacing is 2.5 mm ganged into groups of 8 for trigger. With 8-8-4 configuration it is possible to tag beam crossing. Chambers arranged in a 32 segment geometry and tilted by about 5 degrees to account for lorentz angle effect.

Advantages of placing CSC in Barrel:

- Single Technology for trigger, precision measurement.
- Potentially easier superlayer-superlayer alignment by photo-lithography.
- Potentially improved pattern recognition and reconstruction using 2-D correlated measurement (*we have yet to prove we need 2-D mesurement*).
- Rate capability to $> 10^{34}$ /cm^2 sec.
- Lighter structure with simpler supports (*entire barrel system about 50 tons*).
- Potential simplification in muon system assembly. Each chamber unit < 200 lb.
- Single Technology with Endcap.

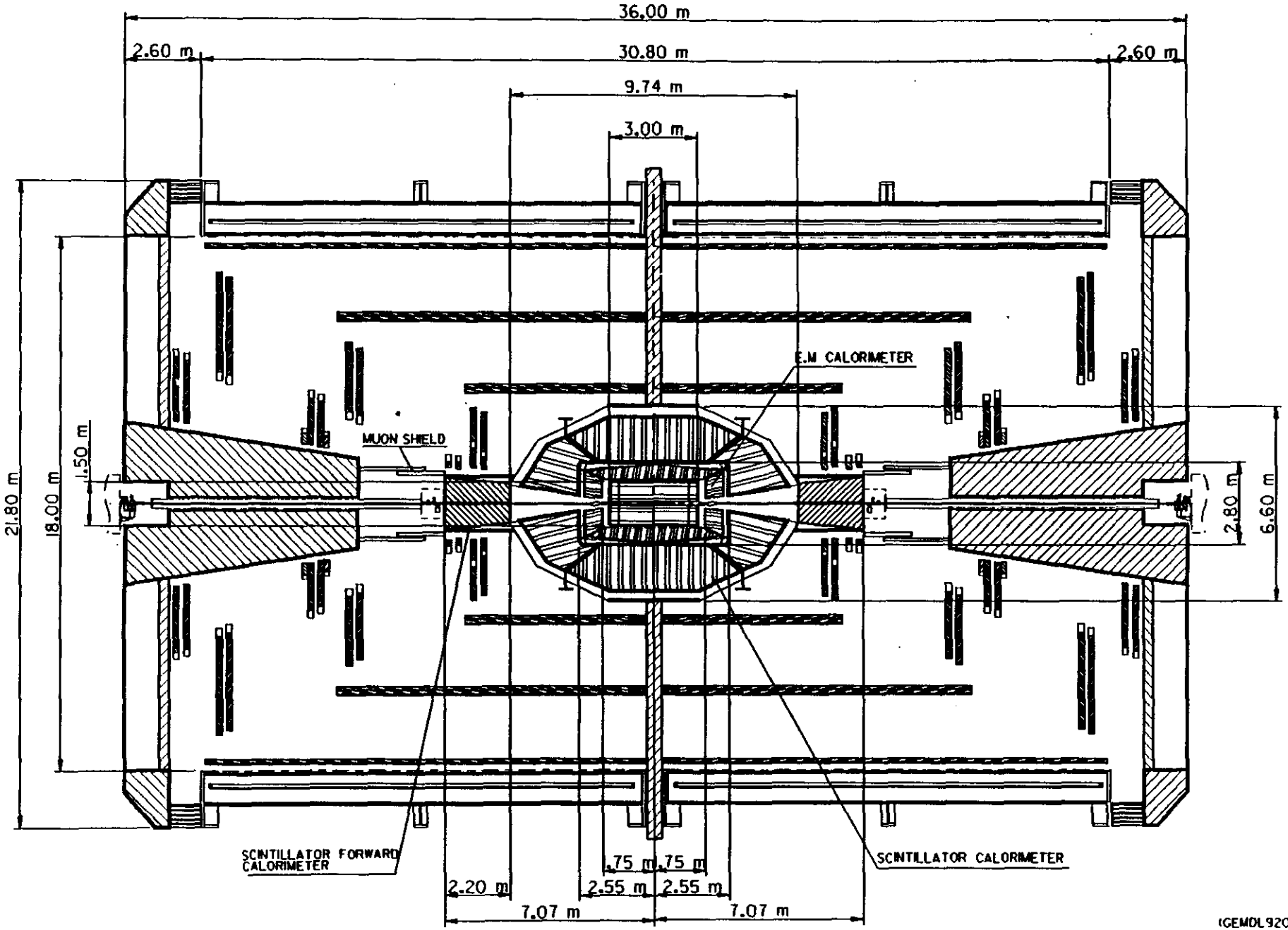
The major areas of concern (aside from general technical questions common to both Endcap and barrel) are:

- Cost of Electronics (about 1 million strips and 1/2 million wires).
- Cost of mechanical construction of 15,000 square meters of active cathode area.

Short Term Plans

- o Cost Review Action items and preparation for next round - June 23 and 24
- o Prepare next Baseline -June 25
- o Complete response to PAC questions for July meeting
- o Write TDR
- o Agree on criteria for technology choices
- o Construct chamber prototypes and test at TTR

GEM DETECTOR LAYOUT
WITH SCINTILLATOR CALORIMETER
OPTION I



(GEMDL920518ZC)

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Presentation by:

K. Morgan

K. Morgan

GEM Central Tracker Team

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Yale University
C. Baltay, Chairman, R. Ben-David, D. Dong, W. Emmet, S. Manly, S. Sen, J. Turk, E. Wolin

Members of the Steering Committee are listed in bold type.

6/4/92-KM

Tracker Update

- Simulations - physicist dedicated to proper integration of CT into global simulations.

- Integration - responding to requests for specifications.
  10mm ex: centering of beam in CT
  ? tolerable non-uniformities in B field.

- Central Tracker Progress Report GEM TN-92-63
  Version 1 - March 1992
  Version 2 - end of June (coincident w/ Baseline 2)

- Design of Central Tracker

  wires not read out

  replaced by stereo pads $\pm 2°$

  no change in Z resolution - 1 mm

thick with a strip pitch of 50 μm. Each pair of sensors provides a space point with a resolution of 10 μm in the $r - \phi$ plane and 3 mm in the $r - z$ projection. The six layers of ladders are organized into three superlayers, each of which provides a track stub to a track finding algorithm. In the forward region, the silicon sensors are mounted into disks with the strips projecting radially inward toward the beam axis. The SM is 200 cm long and extends in a radius from 10 to 35 cm. The total area of silicon ladders in the detector is about 7 m^2 with about 3.5×10^6 strips to be read out. The read out will be highly multiplexed, with 1028 strips to one fiber optic readout channel, for a total readout channel count of 3500.

The outer tracker consists of 8 layers of IPC, both in the barrel region at radii between 35 and 70 cm, and in the forward region which extends from 20 to 70 cm in radius. The 8 layers are arranged in 4 superlayers with 2 layers each. Each barrel layer will consist of 20 chambers, each covering 18° in azimuth, with the largest chamber being 30 cm wide × 200 cm long. The forward layers will be disks divided into ten trapezoidal chambers about 50 cm × 50 cm each.

Each of the chambers will be tilted in azimuth by the Lorentz angle of the gas (~6 to 9°) so that the E × B effect in the 0.8 T field does not degrade the resolution. This tilt also allows the chambers to be overlapped, eliminating dead regions due to electronics and structural elements.

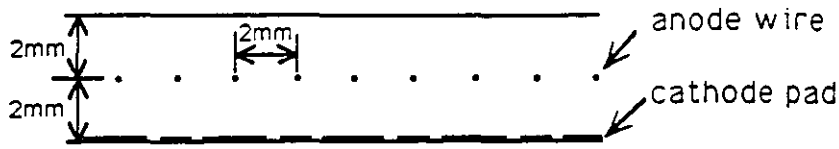
The direction of good resolution in these chevron pad chambers is along the anode wire. Thus, the wires in the barrel chambers will run across the chambers, in the "ϕ direction", keeping the wire length between 15 and 30 cm. In the forward chambers the wires will also run in the "ϕ direction", with wire length between 10 and 40 cm.

In the present design pad sizes are a uniform $\Delta\eta \times \Delta\eta\phi = 0.0007$ in all parts of the tracker. This results in a total of just under 400,000 pads for the entire device.

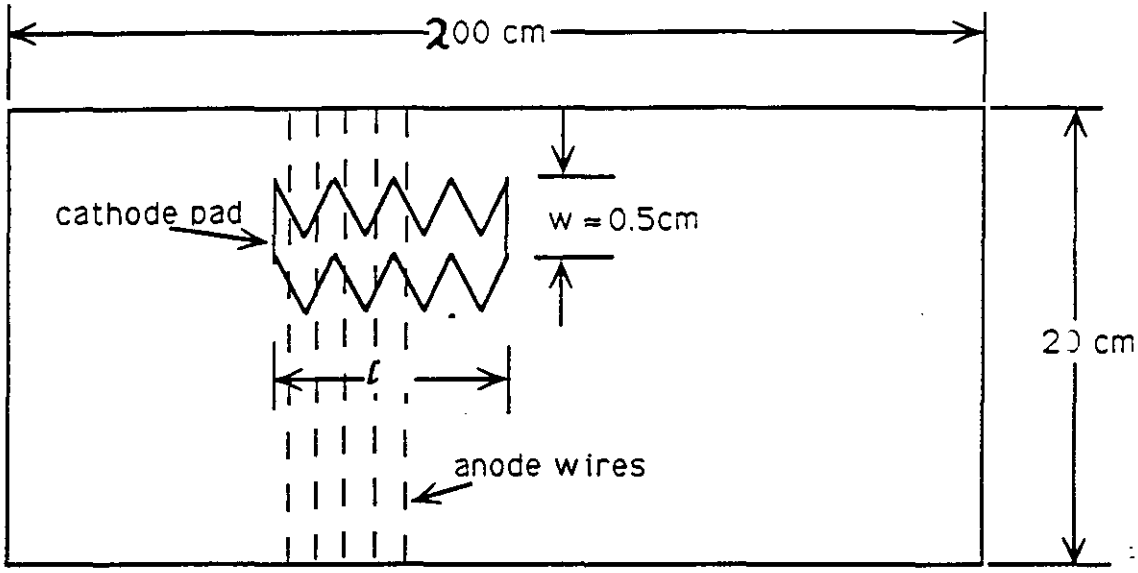
The anode wires will be spaced at 2.0 mm intervals. To obtain precision better than the pad size in the "Θ direction", readout of the anode wires is expected in at least one layer in each superlayer. A digital readout would provide a precision of ~600 mm in this direction. This precision in each of the superlayers will provide the required δz ~1 mm to separate event vertices at a luminosity of 10^{34} cm^{-2} s^{-1}, when the silicon tracker is expected to be out of operation. This would require about 100,000 wires to be read out digitally, which will be multiplexed at a level that satisfies the occupancy requirements.

Source: KM
Updated:

Details of IPC design

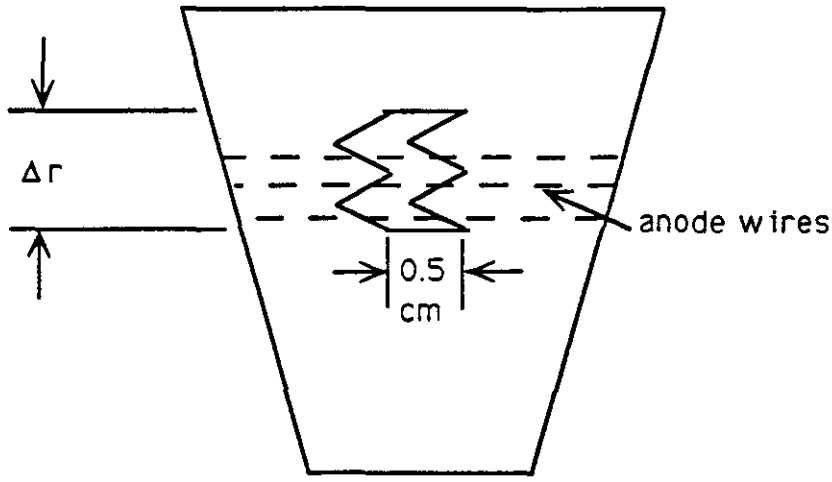


a) Cell geometry viewed along the wire



Resolution sigma ≈ 1% of w ≈ 50 μm
Length of pads ℓ ≈ 2 to 10 cm

b) Pad arrangement in the Barrel Chambers



Resolution sigma ≈ 1% of w ≈ 50 μm
Length of pads Δr ≈ 0.5 to 7.5 cm

c) Pad arrangement in the End Cap Chambers