GEM TN-92-133

Muon Group Meeting - SSCL

July 3, 1992

Abstract:

Agenda, attendees, and transparencies of the GEM Muon Group Meeting held at the SSC Laboratory on July 3, 1992. Agenda items are: General Issues; Discussion of Changes for New Baseline; Electronics Issues; Status Reports of R&D Efforts; Mechanical Engineering Update; Update on Simulations; and Discussion/Review.

GEM MUON MEETING

July 3, 1992

July 3, 92

Name	e-mail	Inst.
V. Polychronakos	POLYCHRON@BNLDAG	BNL
Dan Marlow	PUPHEP::MARLOW	Princeton
Bob Wixted	SSCVX1 :: WIXTED	SSC
Scott Whitaker	BUPHYC:: SCOTT	BU
Michael Danilov	F1SDAN@DHHDESY3	ITEP
Andrey Golutvin	Golutvin@SSCVX1	ITEP
Gena Mitselmakher	MITSELMAKHER@SSCVX1	SSCL
Frank Taylor	MITLNS:: FET	MIT
Chiaki Yanagisawa	SBHEP::CHIAKI CHIAKI@SBHEPNY	Stony Brook
Mike Harris	SSCVX1 :: HARRIS	SSCL
Coleman Johnson	SSCVX1 :: Johncole	"
Louis S. Osborne	Osborne@MITLNS	MIT
Victor Tchistilin	SSCVX1 :: TCHISTILIN	ITEP
ANDREY OSTAPCHUK	OSTAPCHUK@SSCVX1	ITEP
Mike Shaevitz	Shaevitz@Nevis	Columbia (Nevis)
KARL VAN BIBBER	KVB@SLACESA	LLNL
G. Mitselmakher	MITSELMAKHER@SSCVX1	SSCL
A. Korytov	KORYTOV@MITLNS	MIT
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HOWARD BAKER	hbaker@draper.com	DRAPER
Bob Miller	MSUHEP:: MILLER	MSU
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Yuri Bonushkin	BONUSHKIN@SSCVX1	SSC
Valeri Zhilichov	Zhilichov@SSCVX1	Moscow SU
Victor Sarantsev	SARANTSEV@SSCVX1	SSC
Leonid Barabash	SSCVX1:: BARABASH	SSCL

Draft Agenda of 7/3/92 (Friday) GEM Muon Group Meeting:

Any comments?

(1) General Issues: (Taylor) 8:30 AM - 8:45 AM
PAC/Woods Hole meeting preparations

(2) Discussion of changes for new baseline (Group) 8:45 AM - 9:15 AM
(what's needed)

(3) Electronics issues: (Marlow/Atiya) 9:15 AM - 10:00 AM

(4) Status Reports of R&D efforts: 10:00 AM - 12:00 PM
(To cover both mechanical and electrical designs)

- CSC (Polychronakos/Whitaker/Mitselmakher
- CSC UH (Lau)
- RPC (Pless/Wuest)
- PDT (Bromberg/Miller)
- LSDT (Osborne/Korytov)
- CSC-barrel (Atiya)
- TTR status (Mitselmakher)
- Trigger/drift (Barasch!) Baker
- [illegible]

Lunch

(5) Mechanical engineering update (Pohlen/Nimblett) 1:00 PM - 1:30 PM

(6) Update on simulations: (coordinated by Chiaki/Atiya)
- hit level Monte Carlo (Chiaki et al.) 1:30 PM - 3:00 PM
A. Carlevaro

(7) Discussion/Review (Group) 3:00 PM - 3:30 PM

REMARKS

F. E. Taylor

Game Plan:

Technologies:

Present time - constructing full - scale prototypes

8/15/92 - delivery of chambers to TTR

8/20/92 to 9/15/92 - test chambers with cosmics

determine - spatial resolution
operational stability
compatability

8/92 to 10/92 - test CSC at RD5 beam at CERN

9/15/92 to 10/14/92 - evaluate tests

10/15/92 - present results at SSCL and make recommendation

10/15/92 to 12/15/92 - develop choice and write TDR

Choices:

Baseline - 1: Choose LSDT or PDT for barrel
Accept RPC for barrel trigger

Accept CSC for endcaps

Baseline - "2": CSC everywhere

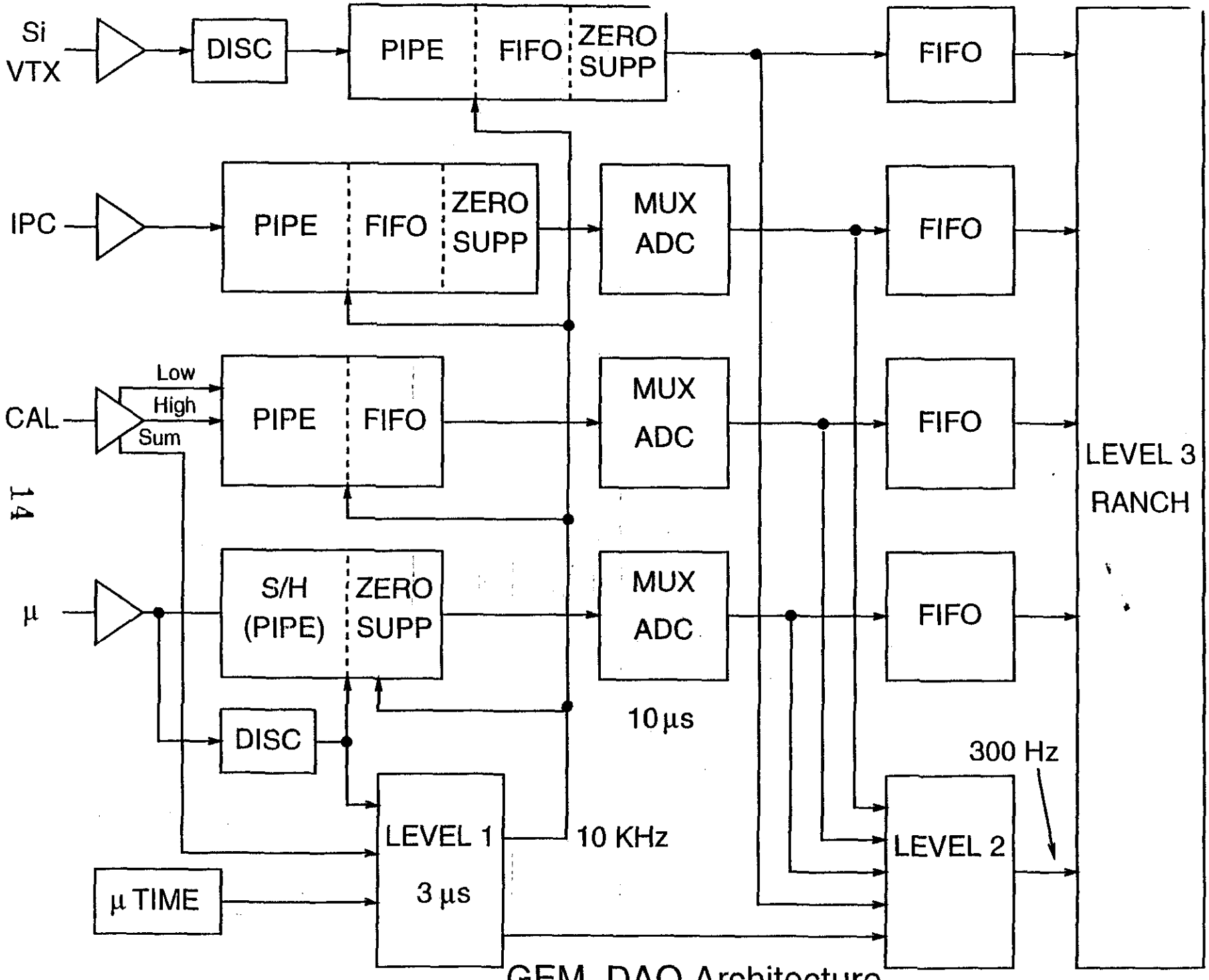
Baseline - "3": A drift option everywhere with PWC trigger

MUON ELECTRONICS

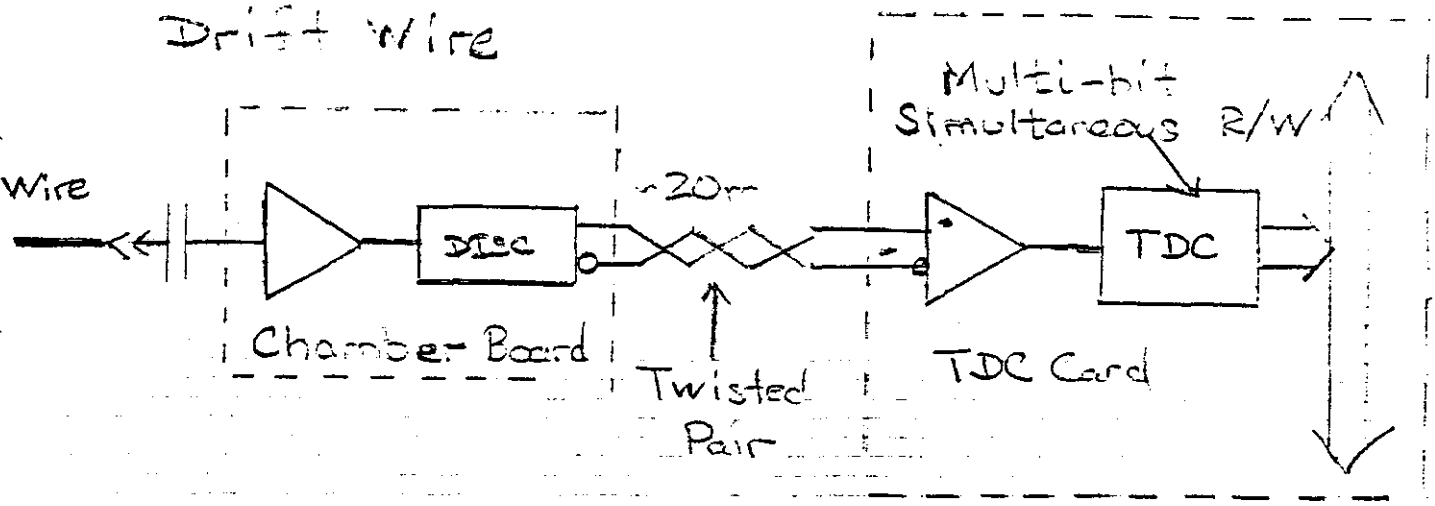
D. Marlow

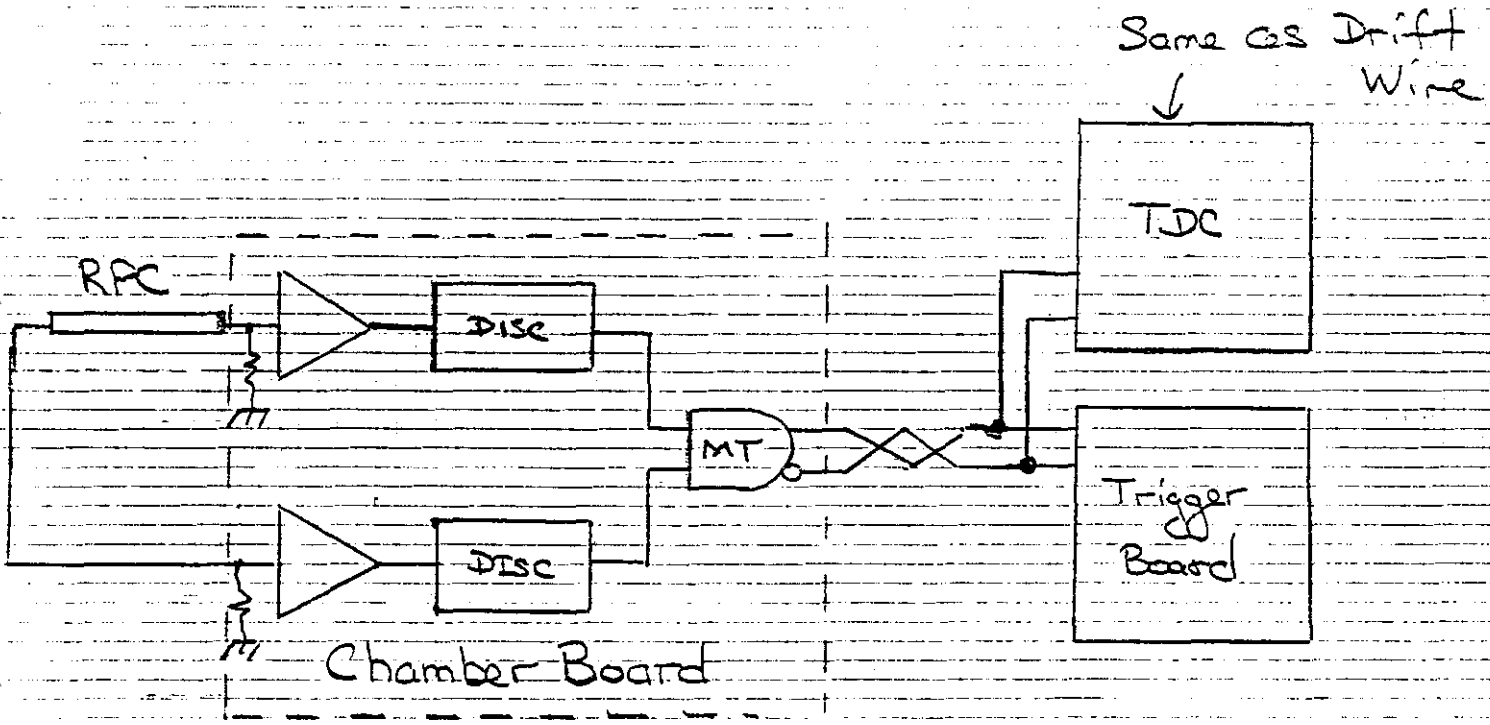
GEM Trigger/DAQ Design Goals				
Level	Rate In	Rate Out	Latency	Comments
1	60 MHz	10 kHz	2 μs	Synchronous, Pipelined
2	100 kHz	300 Hz	$\sim$ 100 μs	Asynchronous, Monotonic
3	3 kHz	10 Hz	—	CPU Ranch

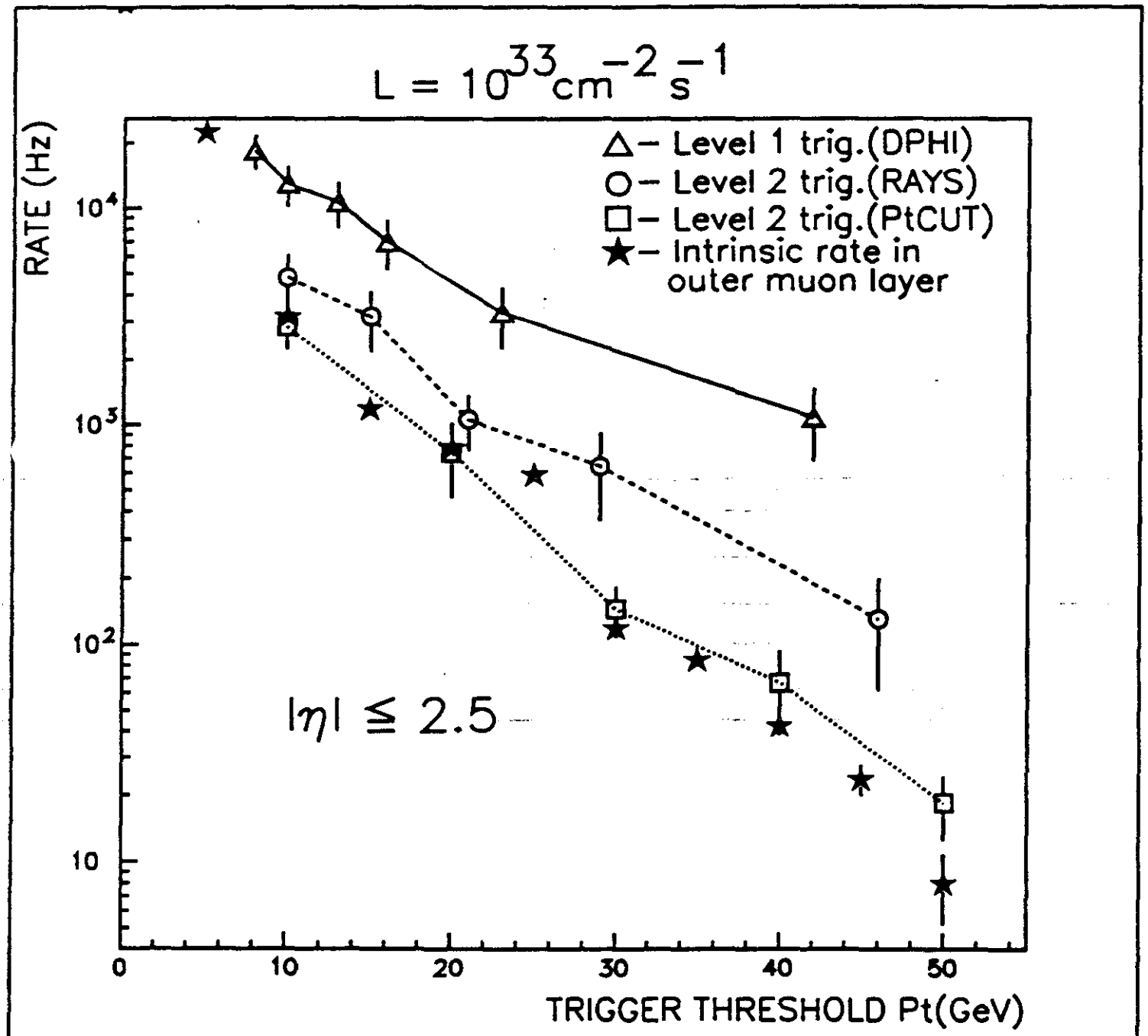
Note: Design *goal* for rate out at each Level is 1/10'th the design *goal* for the input rate handling capacity of the subsequent Level.



GEM DAQ Architecture


Drift Wire
Multi-hit
Simultaneous R/W
Wire
DISC
~20m
TDC
Chamber Board
Twisted
Pair
TDC Card


Same as Drift
Wire
TDC
RPC
DISC
MT
Trigger
Board
DISC
Chamber Board



INTEGRATED SINGLE MUON RATES

M. Seman / Nevis

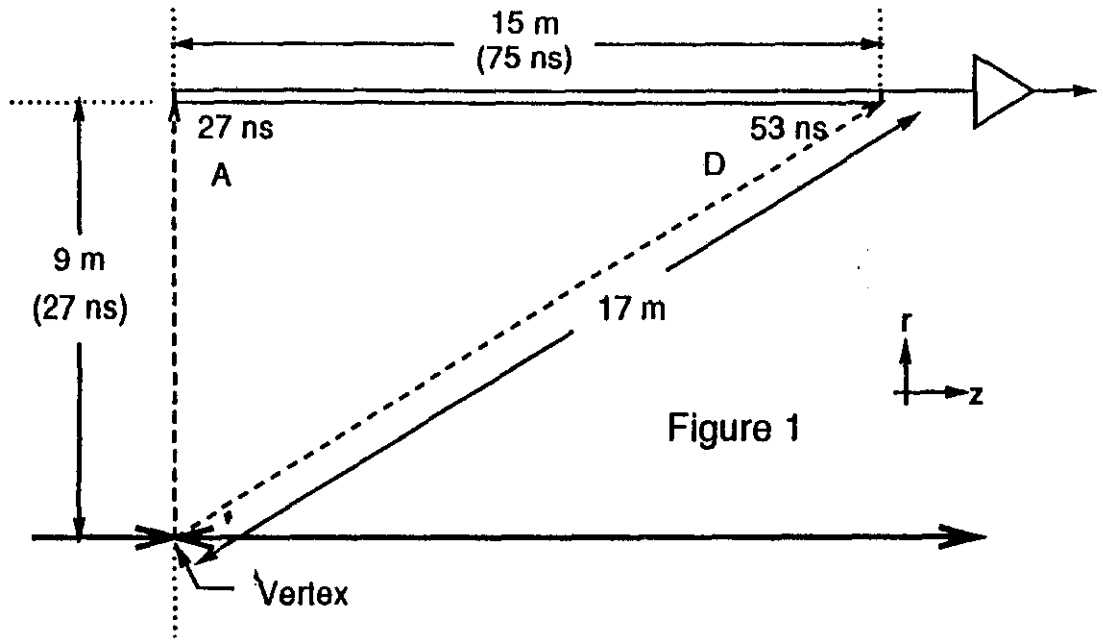


Figure 1

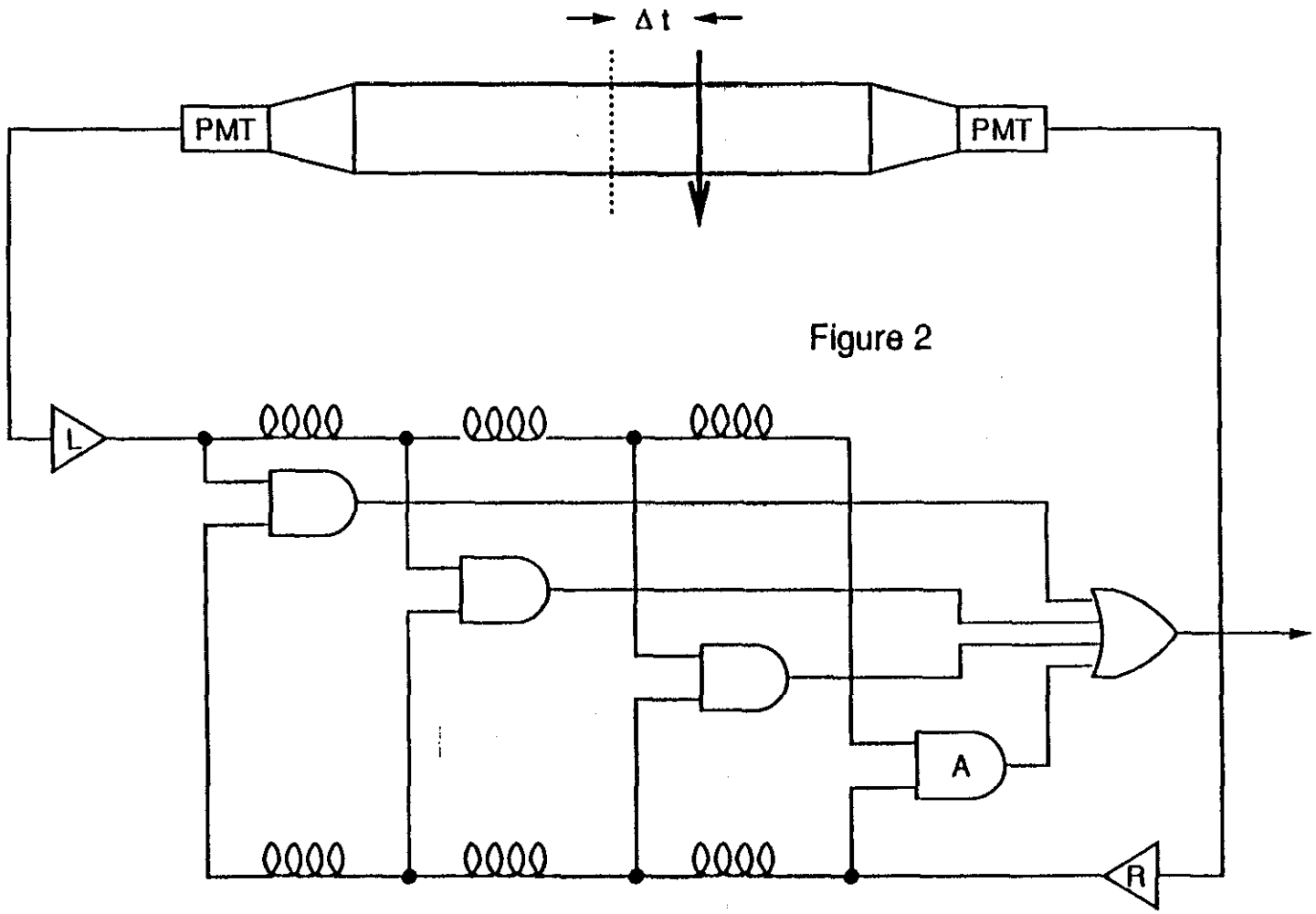


Figure 2

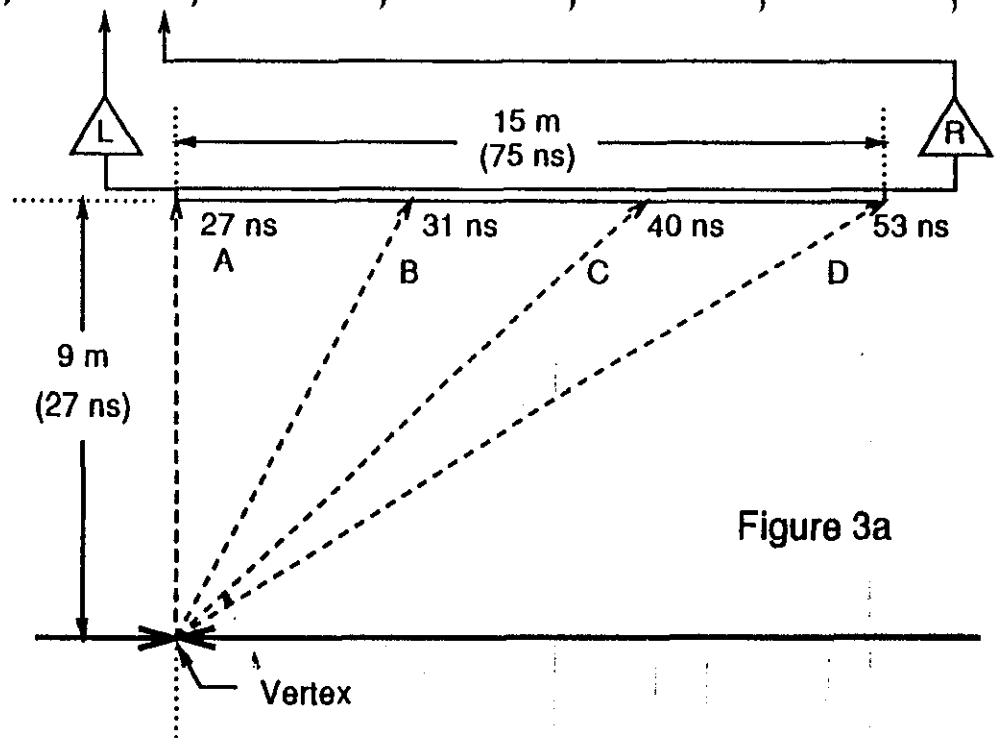


Figure 3a

Arrival Time in ns		
Case	T_L	T_R
A	27	102
B	56	81
C	90	65
D	128	53

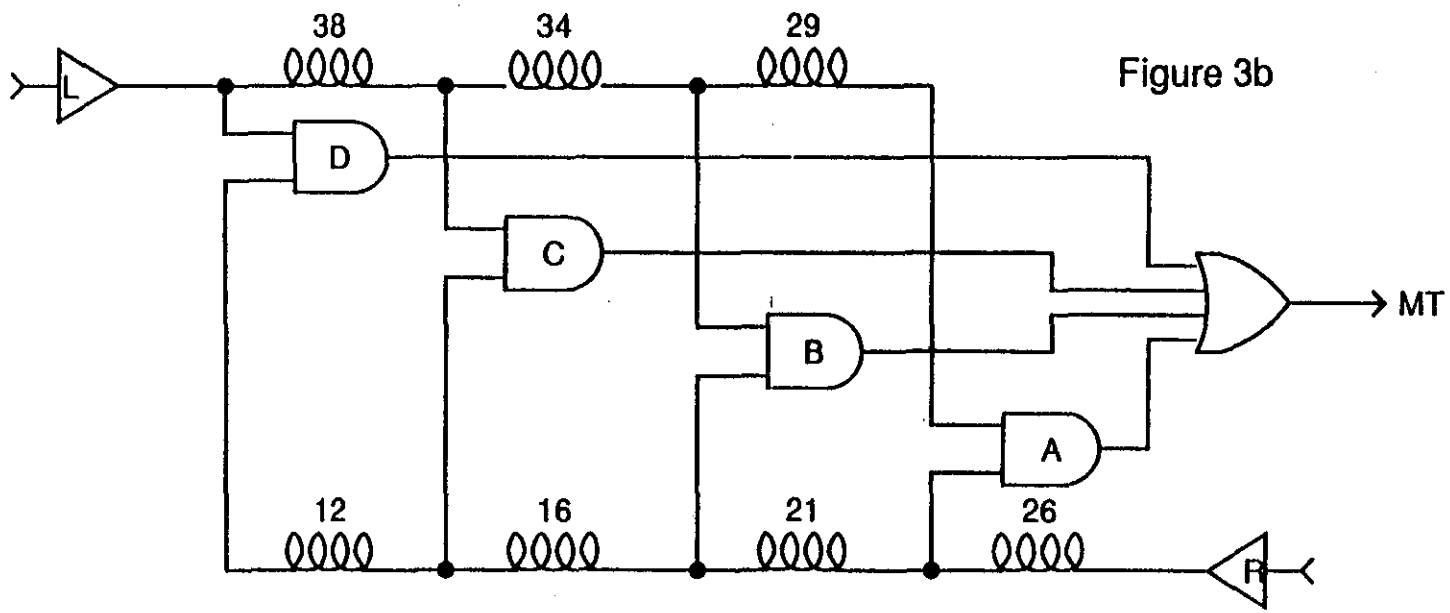
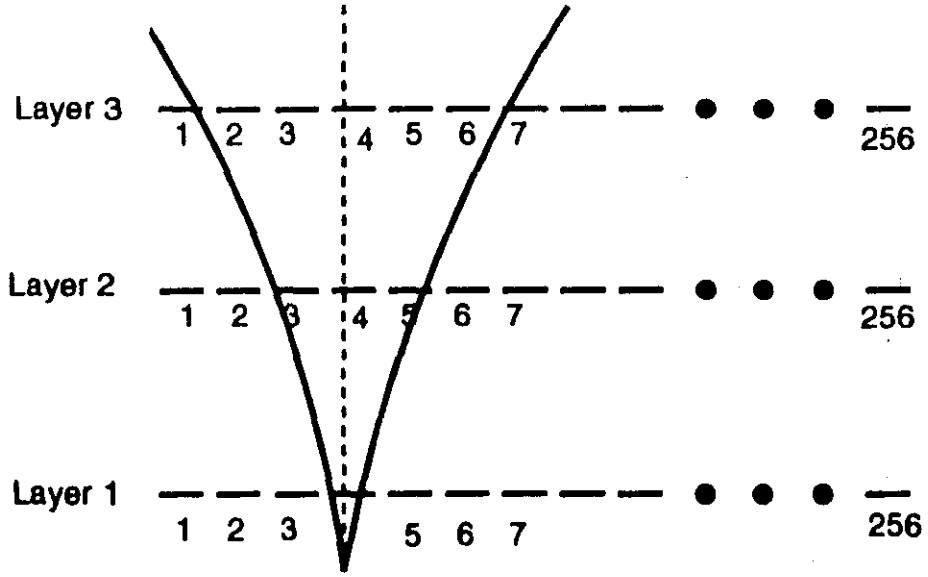
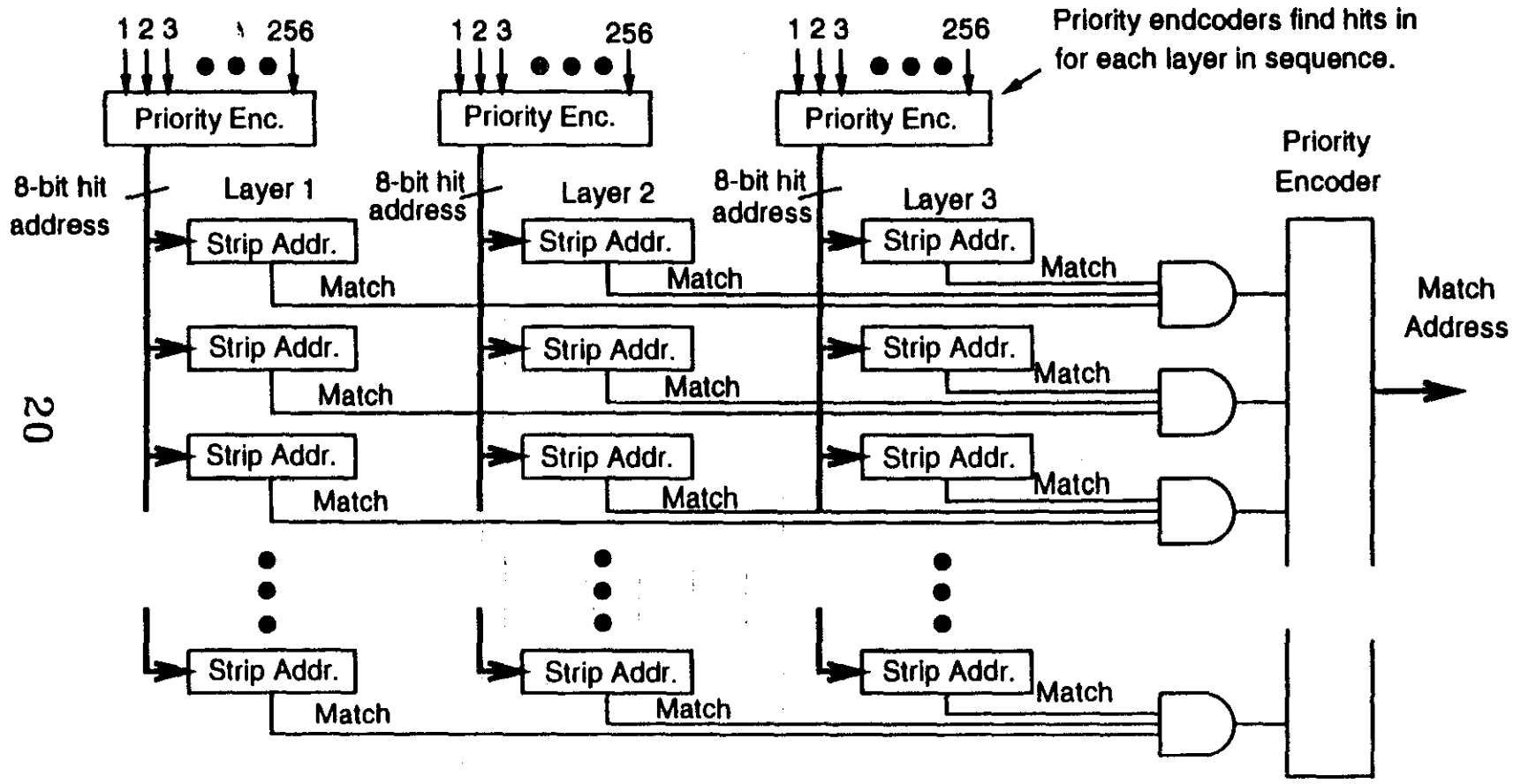
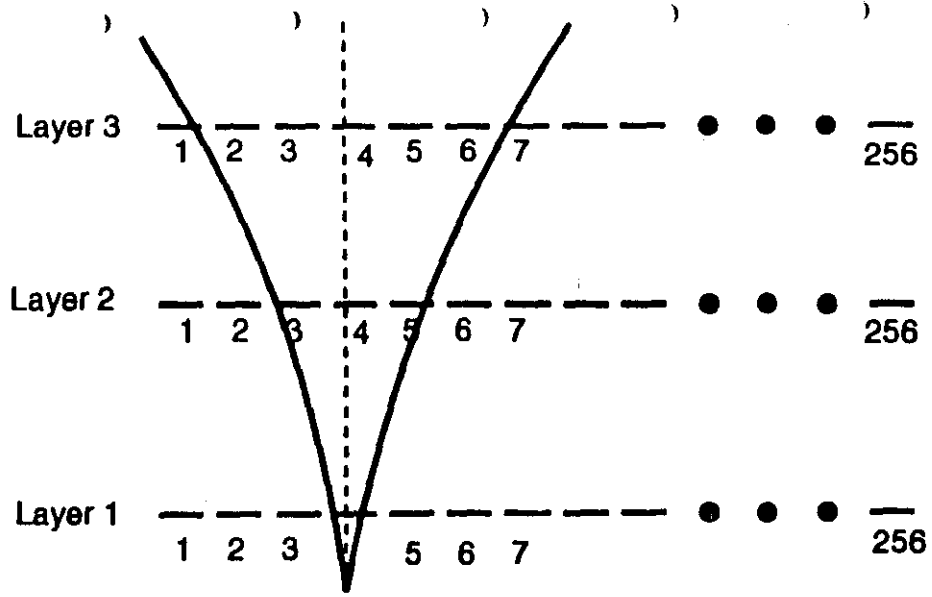


Figure 3b

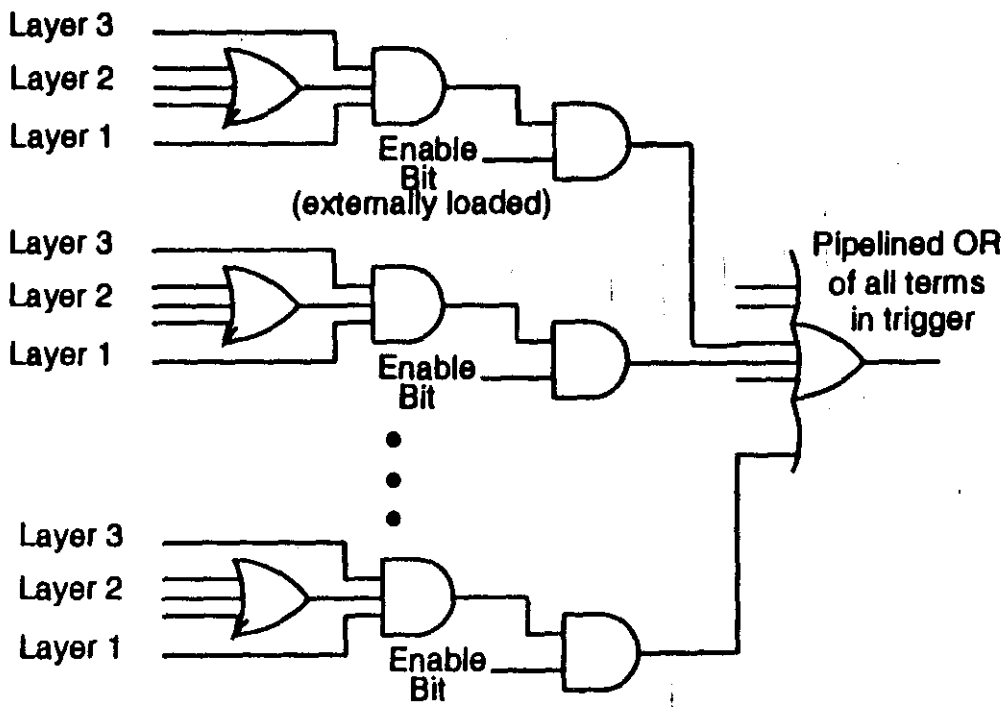


Content Addressable Memory Logic for Muon Trigger





Pipelined Muon Logic



ELECTRONICS

M. Atiya

What do we need in TDR muon electronics

1) Basic Signal Information:

Ionization, gas gain, Pulse width (shaping time

2) Amplifier(s) design & Current R&D status

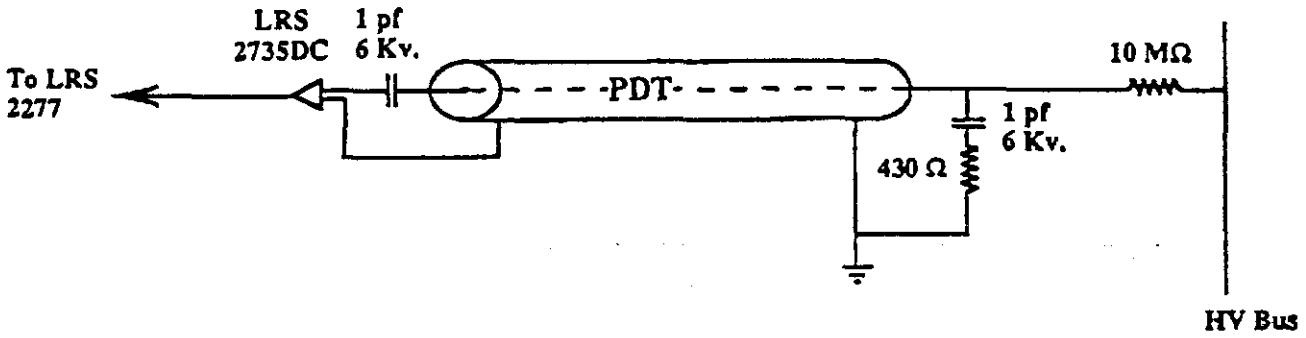
3) Digitization scheme (ADC / TDC etc) & Current R&D status

4) Trigger generation for L1, including any trigger Pipes

5) Readout / DAQ scheme Conceptual design.

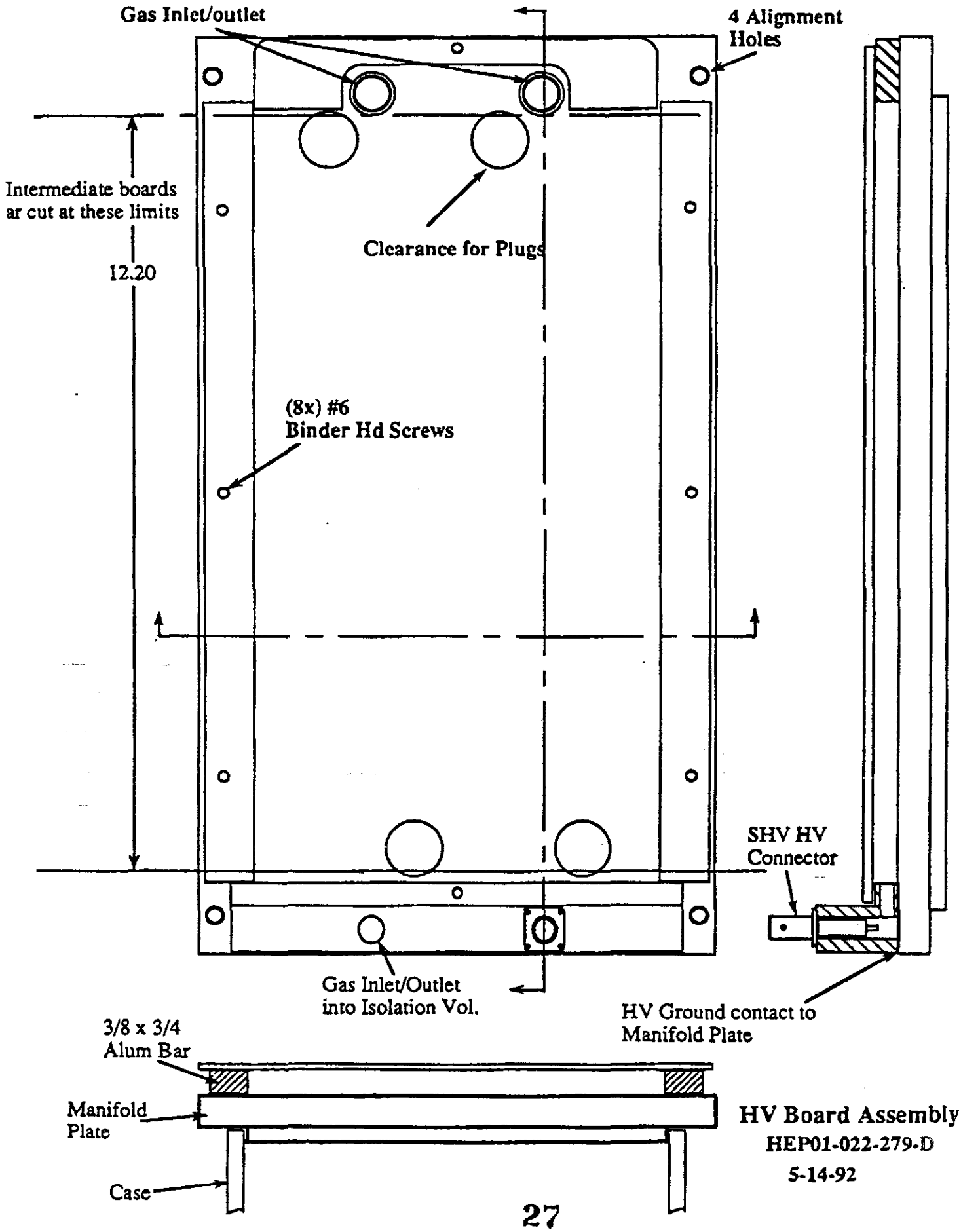
6) High level Signals for Control of digitization, sparsification, deadtime generation

[A nice writeup of Concepts & Philosophy]

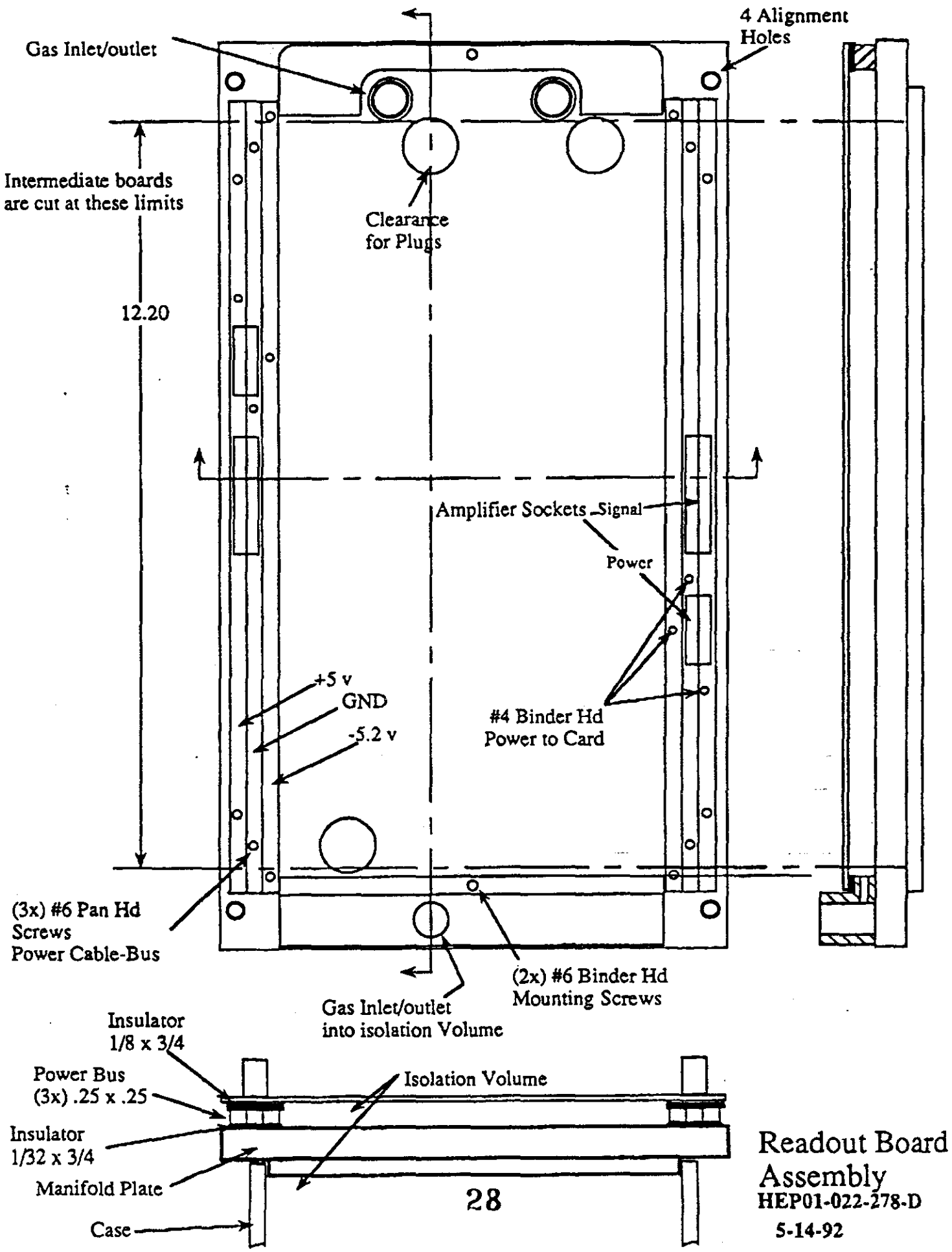


ITEM	PART NO.	DESCRIPTION	QTY.
PARTS LIST			
UNLESS SPECIFIED DECIMALS ± FRACTNS ± ANGLES ± BREAK ALL EDGES DO NOT SCALE DWG		ORIG. R. Miller	6-9-92
		DRAWN	
		PROJECT GEM PDT Prototype	
		MATERIAL	
MICHIGAN STATE UNIVERSITY HIGH ENERGY PHYSICS			
TITLE Termination Diagram			
DWG. NO.		REV.	SCALE

FROM:physics TO: 617 253 1755 JUL 7, 1992 10:21AM P.03



HV Board Assembly
HEP01-022-279-D
5-14-92



Readout Board Assembly
HEP01-022-278-D
5-14-92

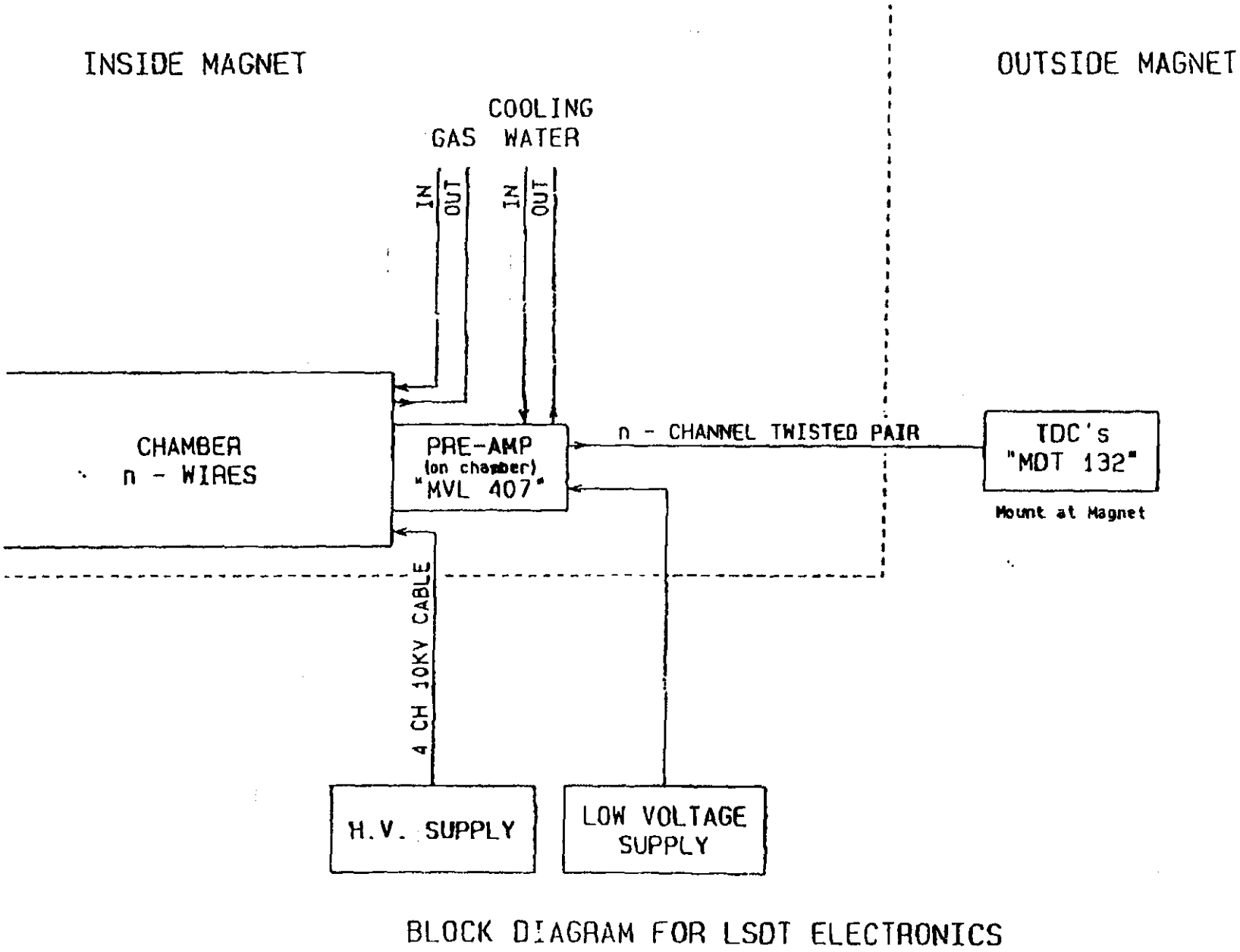
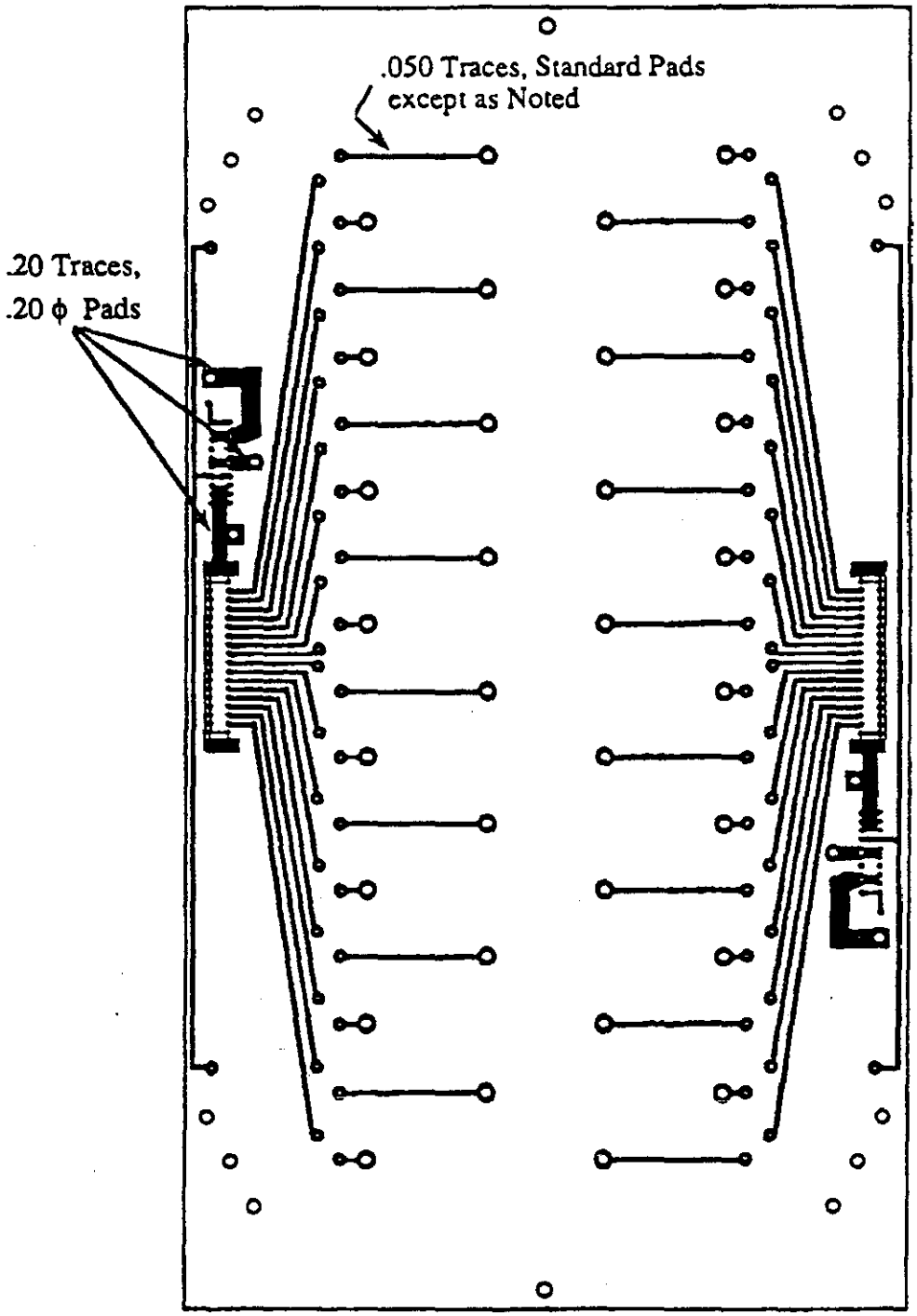
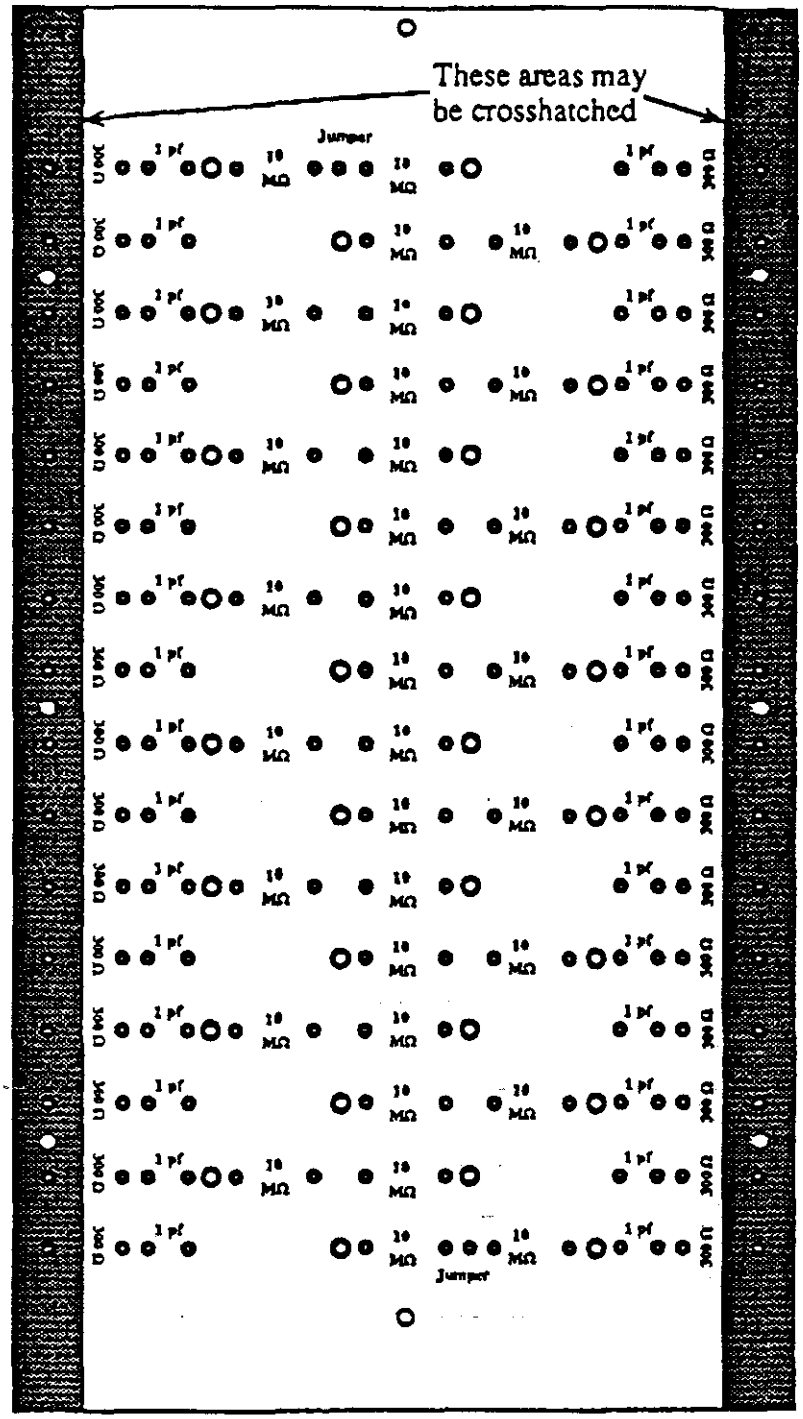


Fig. X.4 Electronic block diagram



ITEM	PART NO.	DESCRIPTION	QTY.
PARTS LIST			
UNLESS SPECIFIED: DECIMALS ± FRACTNS ± ANGLES ± BREAK ALL EDGES DO NOT SCALE DWG	ORIG. R. MILLER		5-12-92
	DRAWN		
	PROJECT GEM-PDT		
	MATERIAL 3/32 " G-10		
MICHIGAN STATE UNIVERSITY HIGH ENERGY PHYSICS			
TITLE READOUT- SOLDER SIDE			
DWG. NO. HEP01-022-278-A		REV. A	SCALE



ITEM	PART NO.	DESCRIPTION	QTY.
PARTS LIST			
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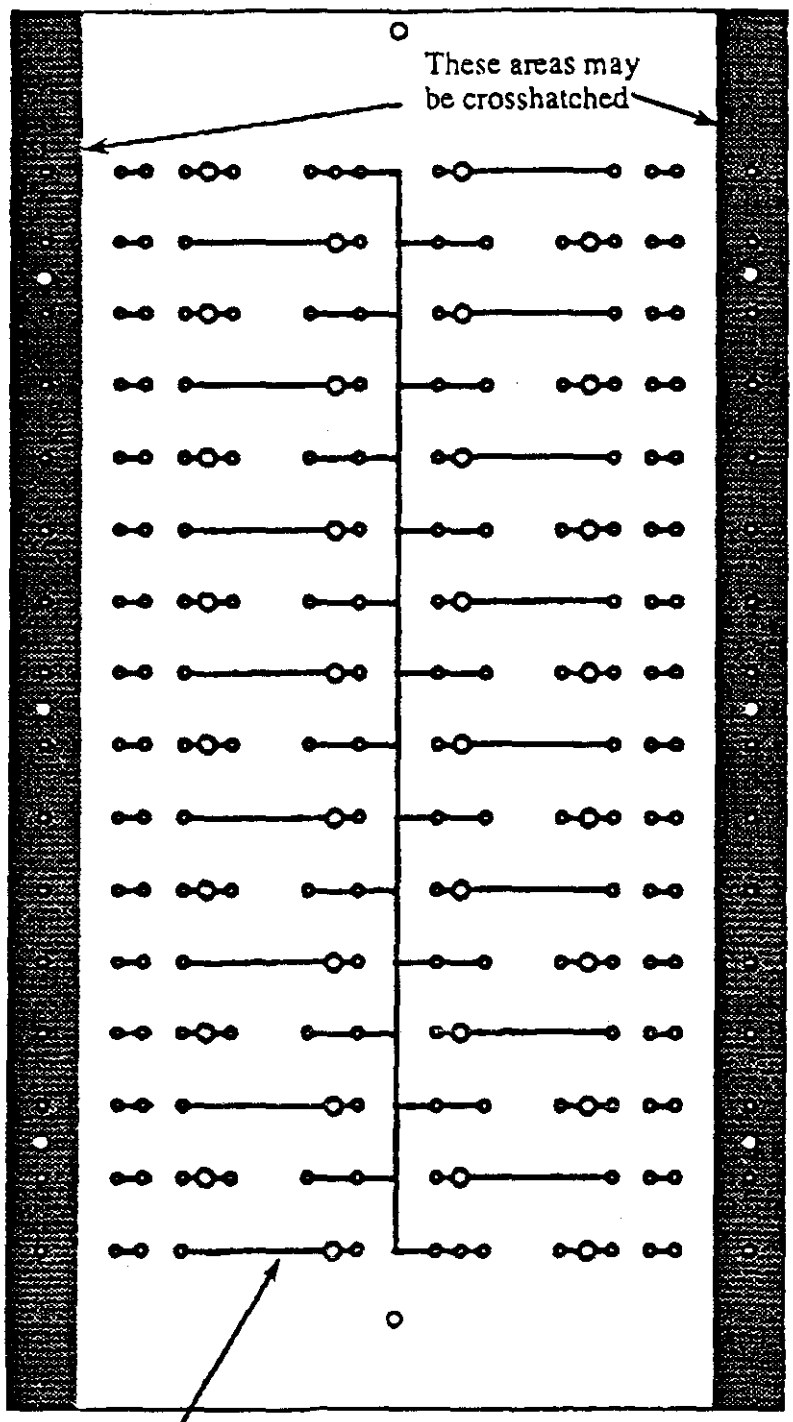
		DRAWN	
		PROJECT GEM-PDT PROTO	
		MATERIAL 3/32" G-10	
MICHIGAN STATE UNIVERSITY HIGH ENERGY PHYSICS			
TITLE HV-BOARD, COMPON'T SIDE			
DWG. NO. HEP01-022-279-B		REV. A	SCALE 1:2



.050 Traces, Standard Pad

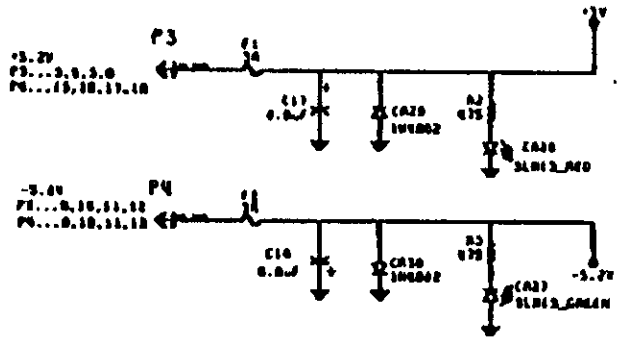
ITEM	PART NO.	DESCRIPTION	QTY.
PARTS LIST			

UNLESS SPECIFIED: DECIMALS ± FRACTNS ± ANGLES ± BREAK ALL EDGES DO NOT SCALE DWG	ORIG. R. MILLER	5-13-92
	DRAWN	
	PROJECT GEM-PDT PROTO	
	MATERIAL 3/32" G-10	

MICHIGAN STATE UNIVERSITY
HIGH ENERGY PHYSICS

TITLE HV- BOARD, SOLDER SIDE

DWG. NO. HEP01-022-279-A REV. A SCALE 1:2



LAST REFERENCE DESIGNATION USED

U9	R16	C95	CR1	Q	P4	J	S	E2	TP	L16	XT	F

LeCroy CORPORATION

27350C

DWG NO: 27350C-31

CSC R & D Status Report

Scott Whitaker

CSC R & D Status Report 3 July 1992

Scott Whitaker, Vinnie Polychronakos

Full scale prototype

Design completed

Hexcel in hand
- Test laminations show flatness to several mils

Frames in production
- Zelux (polycarbonate, 40% glass)
- Flat to 4 mil, parallel to 2 mil over 4 ft

Cathodes -- expected ~ July 20

Electronics

Anode Readout
- Hybrids in production
- Boards designed, being tested

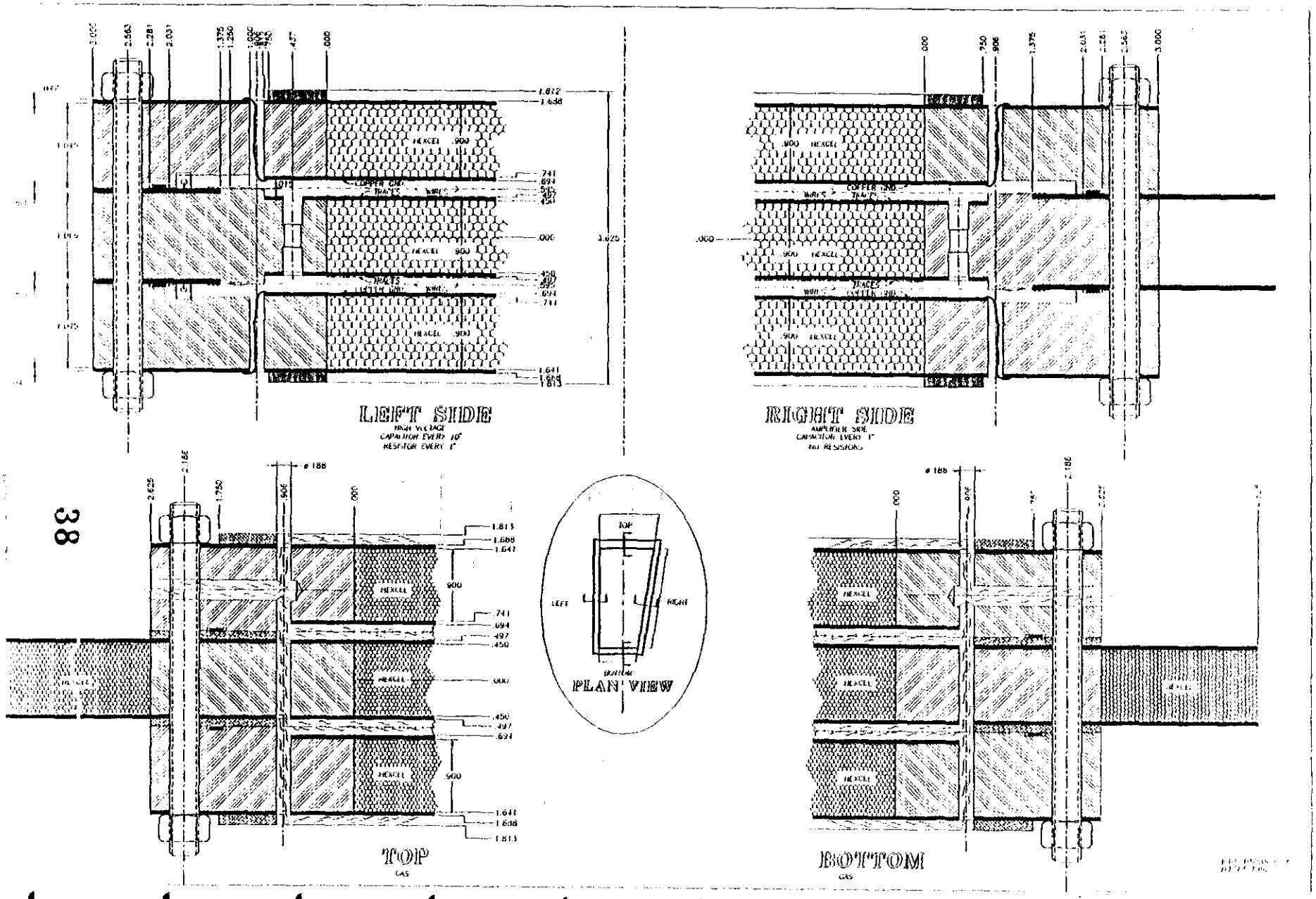
Amplex readout
- BNL: Amplex with preamps
  - preamps ready
  - board being laid out
- BU: Amplex readout without preamps
  - operational

New Amplex-type IC design well advanced (VP)

Data Acquisition

Mac Quadra/GPIB/Camac/Labview operational

PROTOTYPE


LEFT SIDE
HIGH VOLTAGE
CAPACITOR EVERY .10"
RESISTOR EVERY 1"
RIGHT SIDE
AMPLIFIER SIDE
CAPACITOR EVERY 1"
NO RESISTORS
TOP
GAS
PLAN VIEW
BOTTOM
GAS
HEXCEL
COPPER GND
TRACES
WIRES

Gas system

Mass flow control system for CO_2/CF_4 operational

Alignment

Linear Variable Differential Transformers for displacements

- Calibrated
- Under test
- Invar bar, lamination in hand for

LED/lens/Quad cell straightness monitors

- Components for one channel in hand
- Holders under design at Draper
- Electronics (from HU/SDC)
  - One channel fabricated
  - Schematics etc to make more

Monte Carlo Studies

Microscopic processes (V. Cherniatin)

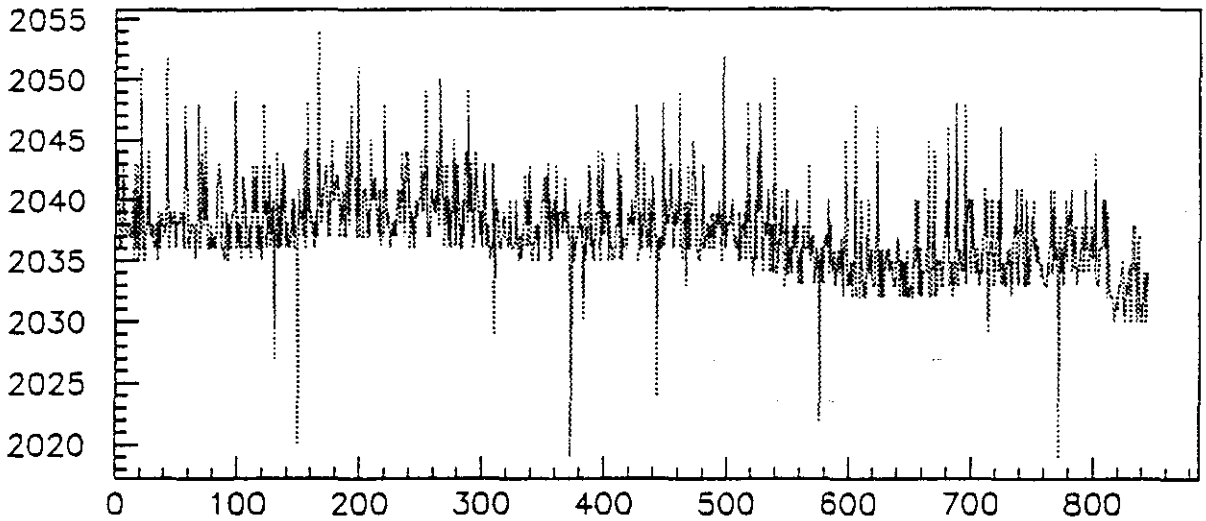
- Clustering, diffusion, Lorentz,...
- ==> Resolution limit ~ 30--40 microns

Hit-level MC (C. Yanigasawa)

- Pattern recognition
- Triggering

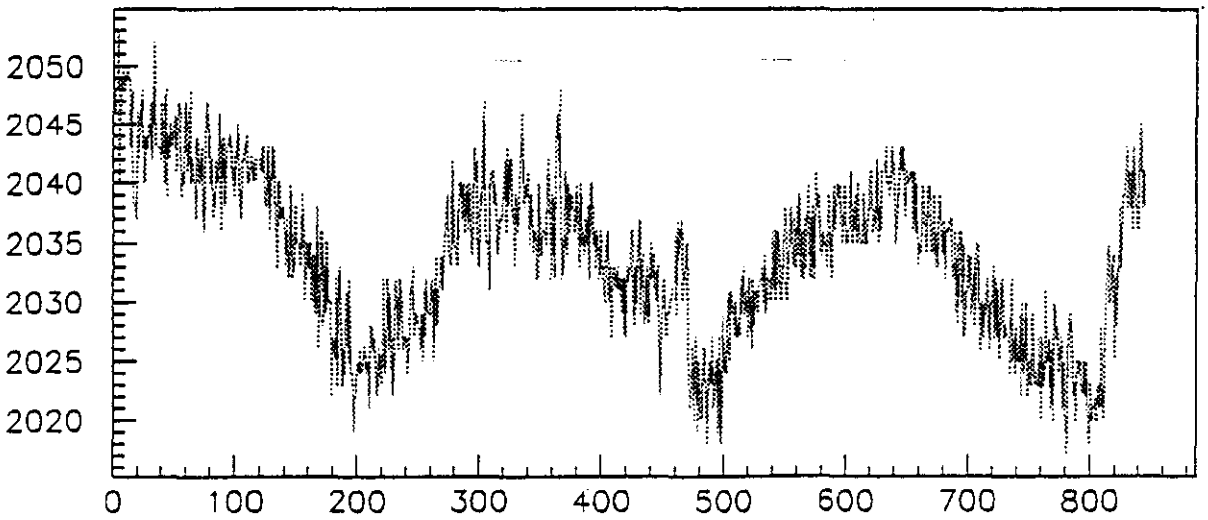
92/06/29 14.34

LVDT



$\frac{1.6\,\mu m}{\text{ADC count}}$

Temperature



$\sim \pm 2^{\circ}C$

Test Detectors

Det2 -- 10cm x 15 cm active area
Up and running

Neutron tests -- $\varepsilon \sim 0.5\%$ food for thought!

Amplex readout via LRS 2259
Noise < 2000 electrons
Resolution < 150 microns -- Fe55 xrays
(Limited by parallax in collimator)

Det3 -- compact size prototype 20" x 20"

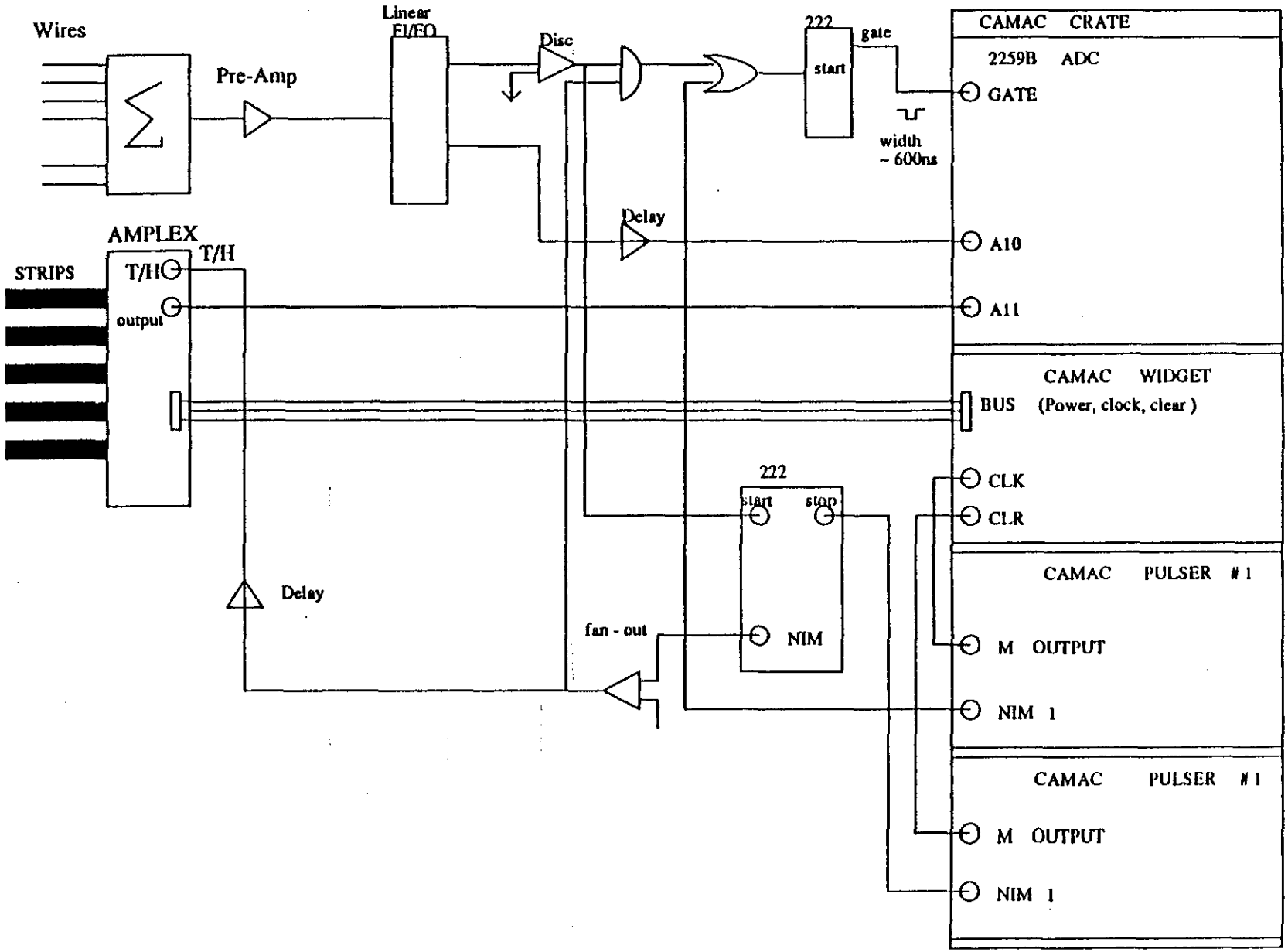
Designed and under fabrication

Anode readout will use ORNL boards

Cathode readout can be BU or BNL style...

Precision cathode surveyed (Draper) --
surprisingly good!

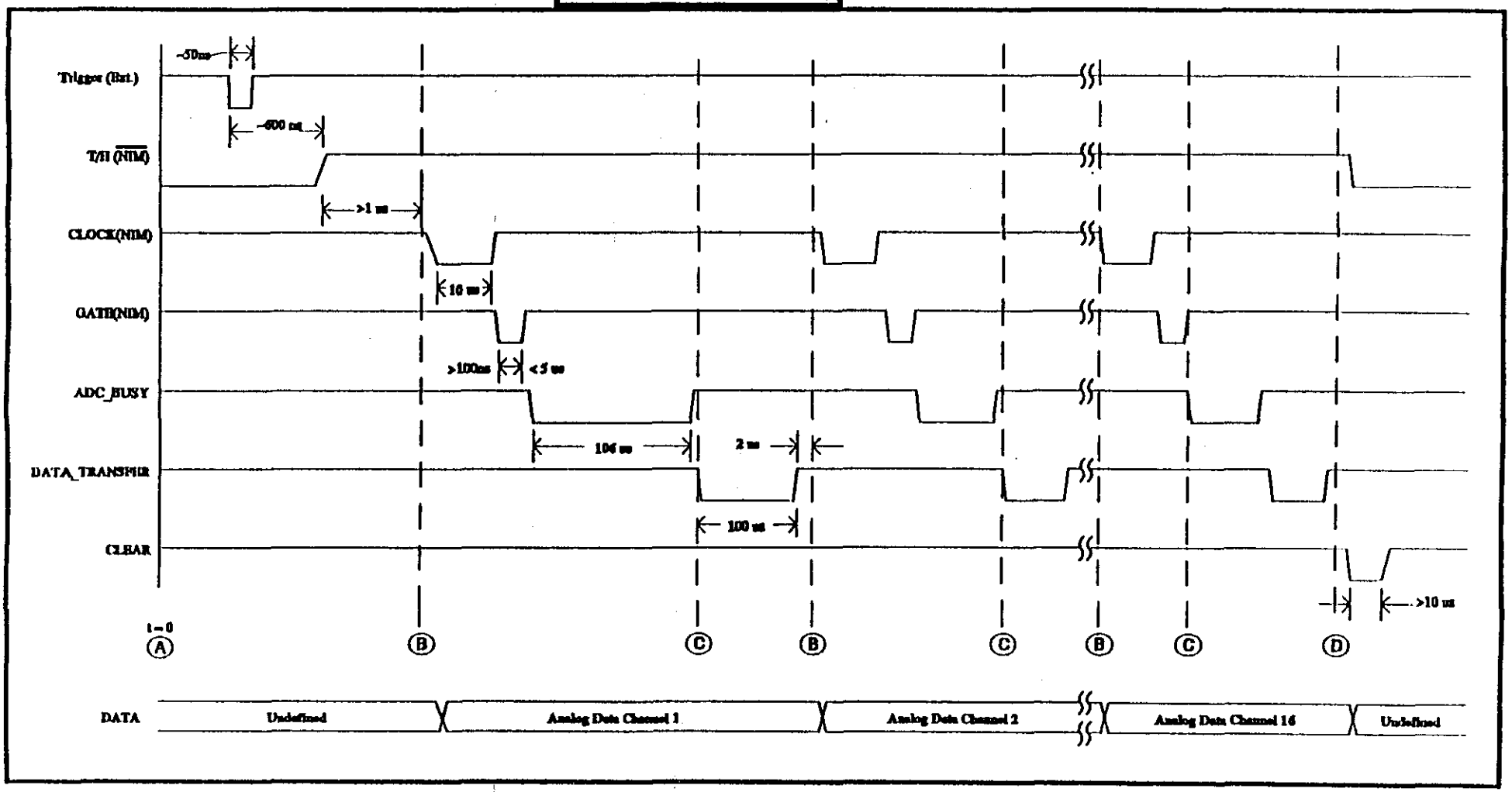
Strip-to-strip capacitance measurements also good

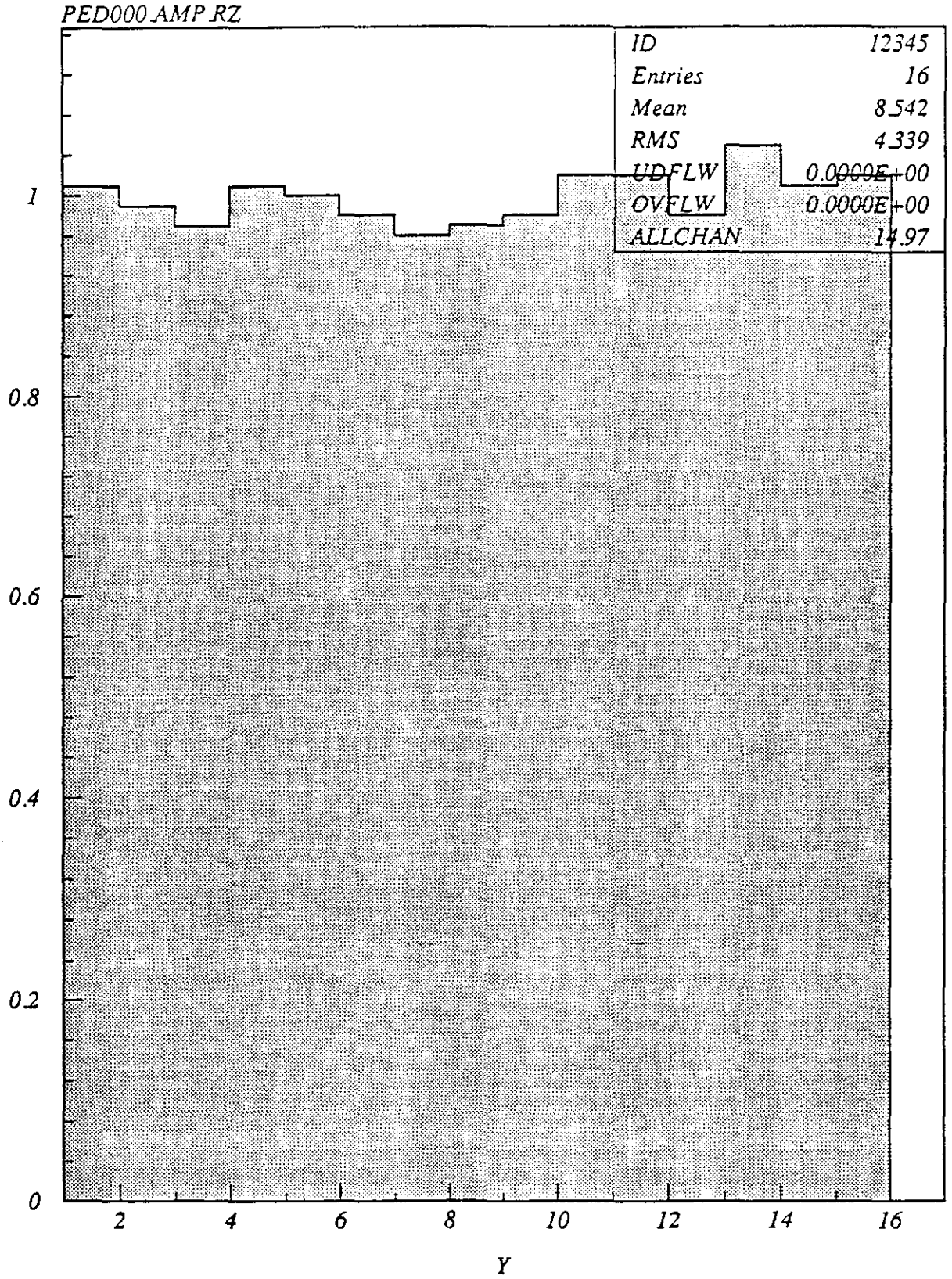


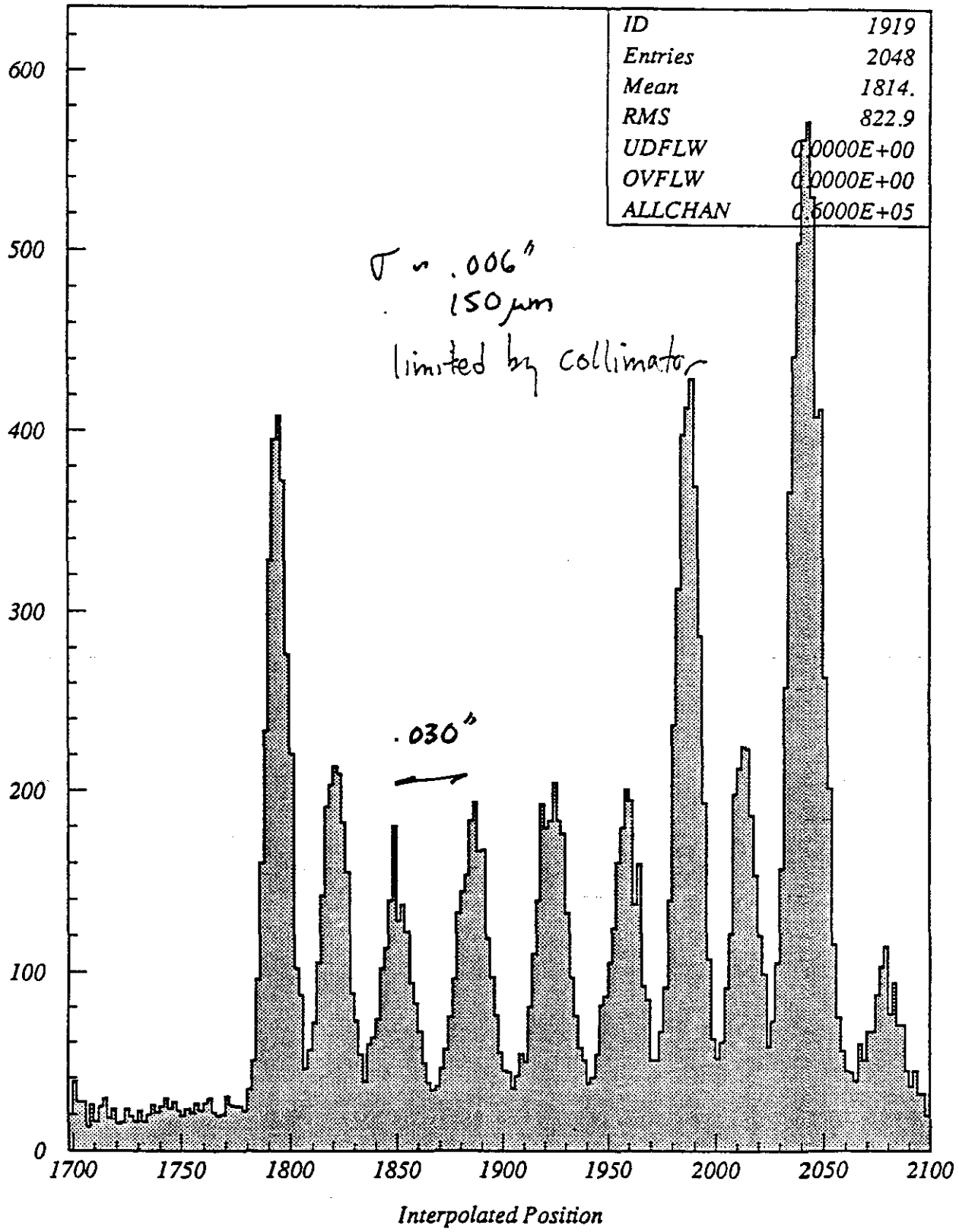
SMALL CHAMBER TEST ELECTRONICS JUN 22 JMC

Amplex Readout Timing Diagram

22 JUN 92 - GSV




PED000 AMP RZ
ID 12345
Entries 16
Mean 8.542
RMS 4.339
UDFLW 0.0000E+00
OVFLW 0.0000E+00
ALLCHAN 14.97
1
0.8
0.6
0.4
0.2
0
2
4
6
8
10
12
14
16
Y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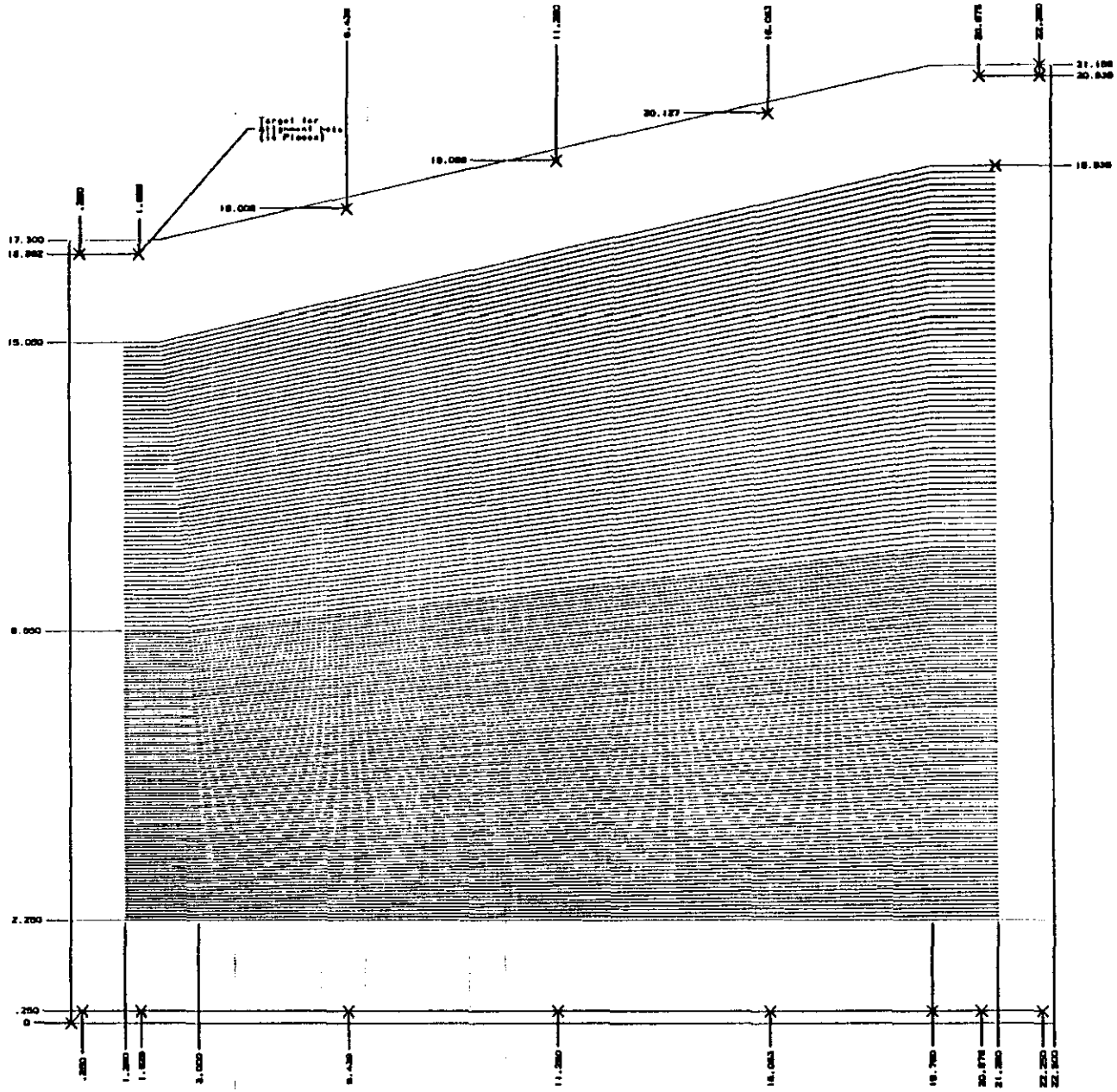
Entries 2048
Mean 1814.
RMS 822.9
UDFLW 0.0000E+00
OVFLW 0.0000E+00
ALLCHAN 0.6000E+05
σ ~ .006"
150 μm
limited by collimator
.030"
600
500
400
300
200
100
0
1700
1750
1800
1850
1900
1950
2000
2050
2100
Interpolated Position



NOTE: Each Superstrip covers 1930 degrees. Lower 32 superstrips are divided into 3 equal positions by .01" spaces, while upper 32 superstrips are divided into 2 equal positions by .01" spacer.

2.0		21 Jan 1982	32 Single Floating Birls	
1.0		8 Jan 1982	array board, hole target	

BOSTON UNIVERSITY
PHYSICS DEPARTMENT

CBC PROTOTYPE PRECISION CATHODE

Spatial Cathode

CBC

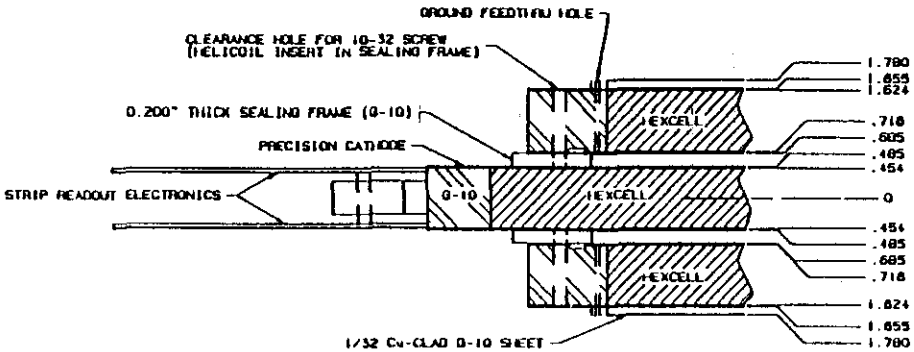
.031 Cu Clad FR-4

10 Jan 82

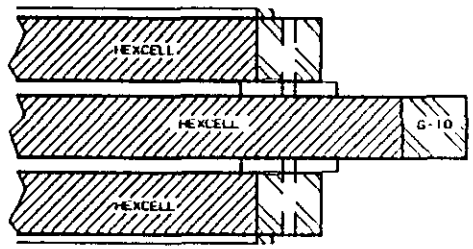
CSC DOUBLET -- CONCEPTUAL DESIGN

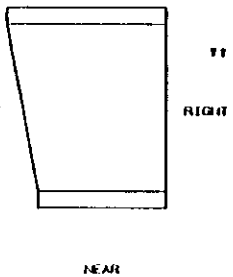
"NEAR" SIDE CUT-AWAY

SCALE: 1:3

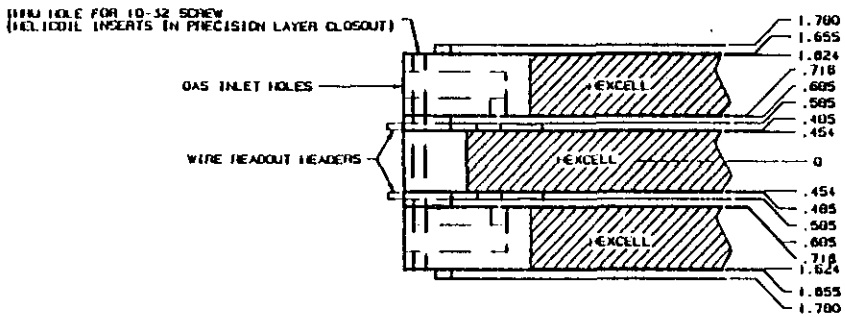


"FAR" SIDE CUT-AWAY

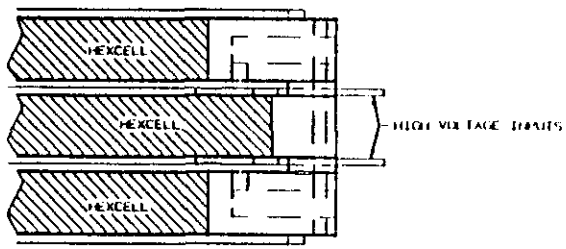




"LEFT" SIDE CUT-AWAY



"RIGHT" SIDE CUT-AWAY

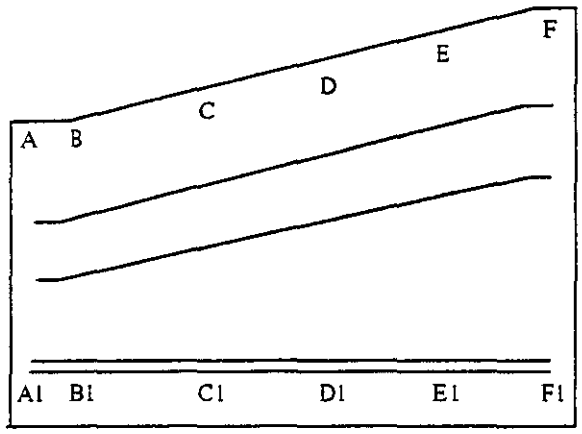


Measurements of Targets on Det3 Cathode

Measurements of targets etched onto precision cathodes for BU Det 3:

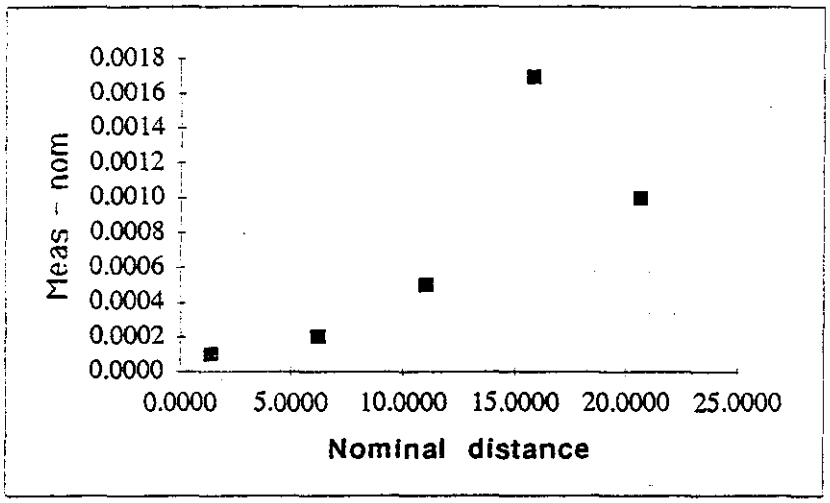
Boards from MPC (Lowell, MA)

Measured at Draper Lab



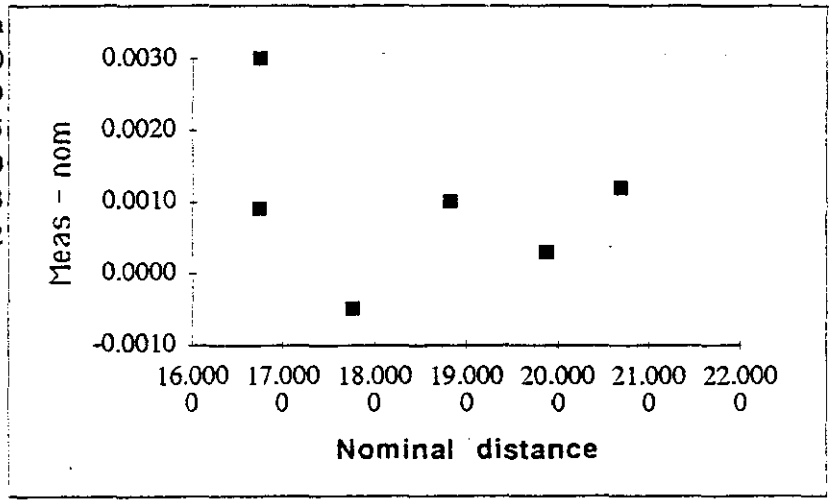
1. Along strips -- straight -- from A1

point	nominal	meas-nom
B1	1.3750	0.0001
C1	6.1880	0.0002
D1	11.0000	0.0005
E1	15.8130	0.0017
F1	20.6250	0.0010



2. Across strips

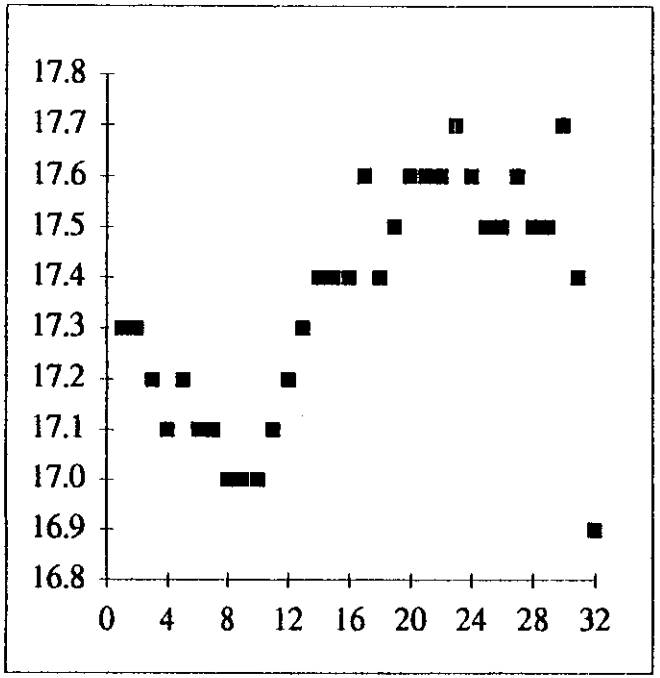
meas. path	nominal	meas-nom
A-A1	16.7420	0.0030
B-B1	16.7420	0.0009
C-C1	17.7580	-0.0005
D-D1	18.8180	0.0010
E-E1	19.8770	0.0003
F-F1	20.6890	0.0012



Strip-to-strip Capacitance Measurements 22-Jun-92

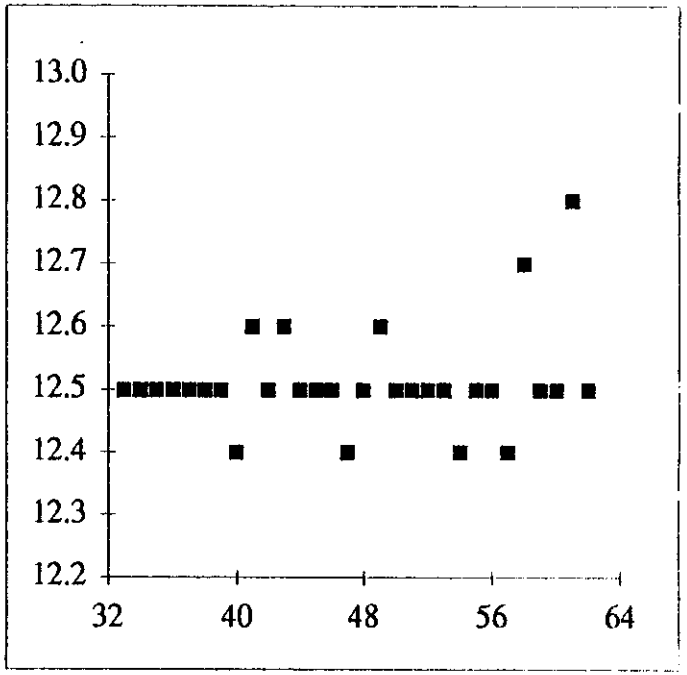
1	17.3
2	17.3
3	17.2
4	17.1
5	17.2
6	17.1
7	17.1
8	17.0
9	17.0
10	17.0
11	17.1
12	17.2
13	17.3
14	17.4
15	17.4
16	17.4
17	17.6
18	17.4
19	17.5
20	17.6
21	17.6
22	17.6
23	17.7
24	17.6
25	17.5
26	17.5
27	17.6
28	17.5
29	17.5
30	17.7
31	17.4
32	16.9

Single Intermediate Strip



33	12.5
34	12.5
35	12.5
36	12.5
37	12.5
38	12.5
39	12.5
40	12.4
41	12.6
42	12.5
43	12.6
44	12.5
45	12.5
46	12.5
47	12.4
48	12.5
49	12.6
50	12.5
51	12.5
52	12.5
53	12.5
54	12.4
55	12.5
56	12.5
57	12.4
58	12.7
59	12.5
60	12.5
61	12.8
62	12.5

Two Intermediate Strip



Cathode Strip PCB Capacitive Coupling

Adjacent Strip Measurements

Single Floating Strip Configuration

$$\langle C_p \rangle = 17.37 \text{ pF}$$

$$\sigma_{C_p} = 0.22 \text{ pF}$$

Double Floating Strip Configuration

$$\langle C_p \rangle = 12.52 \text{ pF}$$

$$\sigma_{C_p} = 0.08 \text{ pF}$$

Long range coupling

1	0.2
2	0.4
3	0.5
4	0.6
5	0.7
6	0.8
7	1.0
8	1.2
9	1.5
10	1.8
11	2.2
12	2.9
13	3.7
14	8.2
15	17.4 - center for top
16	17.3 - center for bottom
17	8.2
18	3.7
19	2.9
20	2.2
21	1.8
22	1.5
23	1.2
24	1.0
25	0.8
26	0.7
27	0.6
28	0.5
29	0.4
30	0.2

CSC IN BARREL

Maged ATIYA

Near term goals:

(What do we need to be competitive & for the TDR)

1) Finish BU+BNL Prototype by 9/15/92.

2) Measure B-field effects by 10/15/92.

3) Finish Monte Carlo & beam studies of muon radiation effects.

4) Have a preliminary design for support structure & alignment

5) Do a cost estimates of the above using both existing estimates & refined estimates including non-US contributions.

Desirable Schedule for Barrel CSC

1998 Installation Complete

↕ Construction + Installation

1994 Begin Construction of 20,000 m^2

Design fixed

1993 "Final" Prototype Complete

To achieve above schedule we need to:

1) Settle on Support structure (i.e. chamber sizes)
2) Settle on alignment scheme since it is built into Cathode Planes
3) Settle on Commercial Production of Cathode Planes
4) Settle on design of on-board electronics

All of the above needs to be done by ~ July 1993

CATHODE STRIP CHAMBERS AT U. OF H.

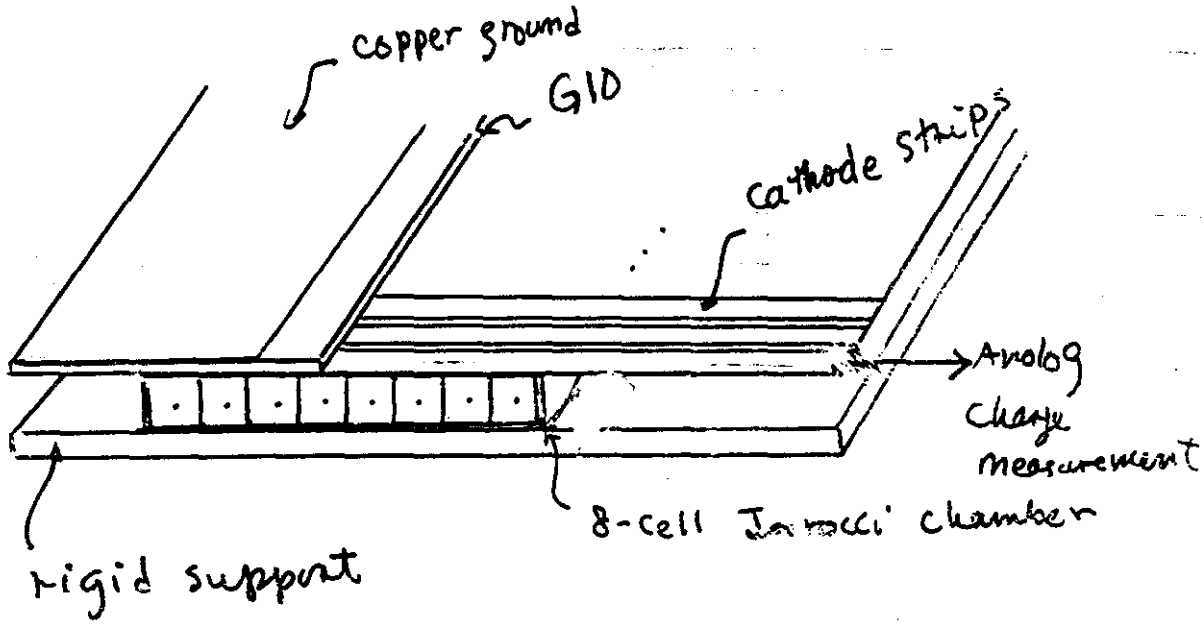
Kwong Lau

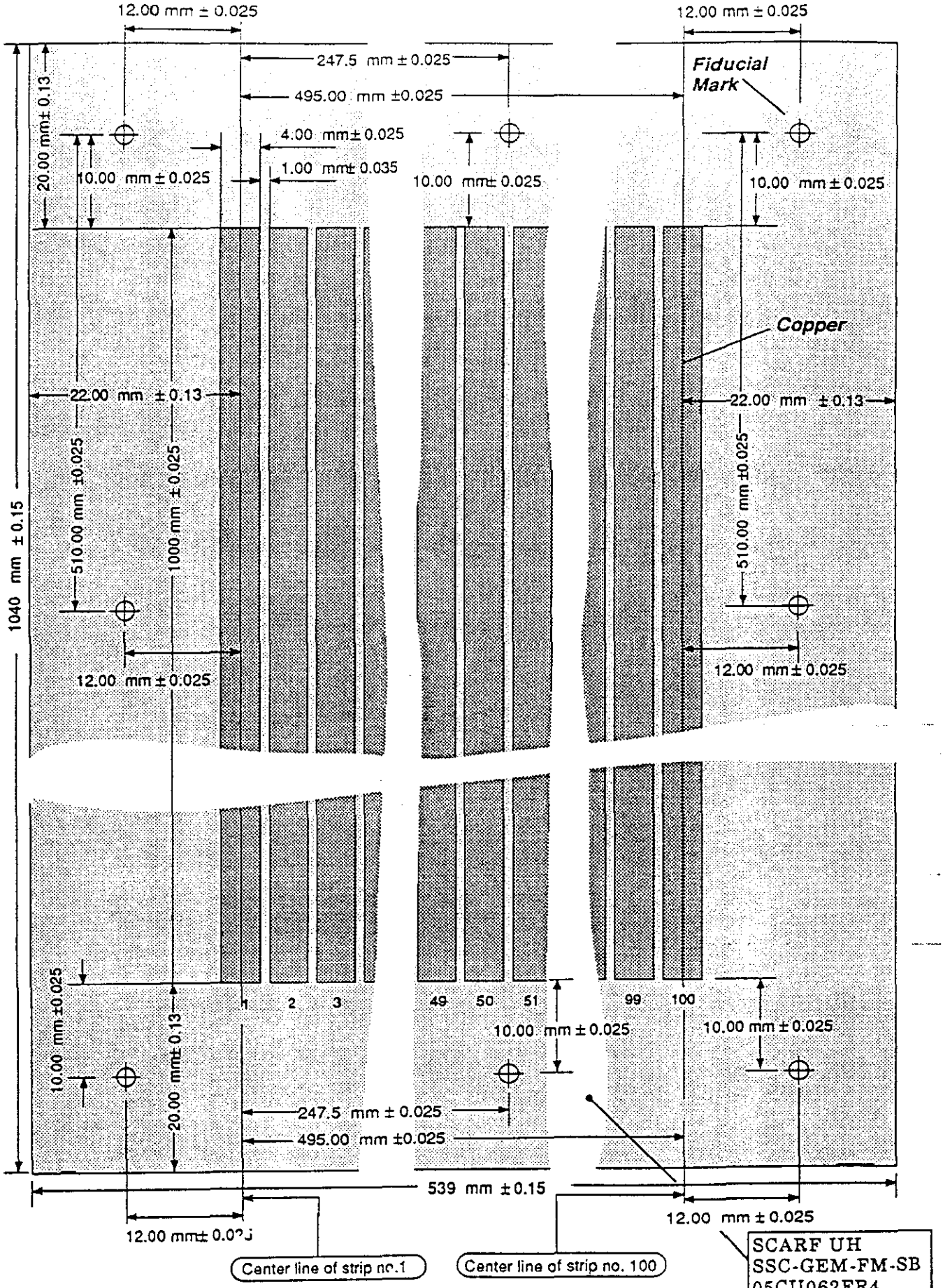
Kwong Lau
~~3/5/92~~

Cathode Strip Chamber (CSC) ~~5/5/92~~ 7/3/92

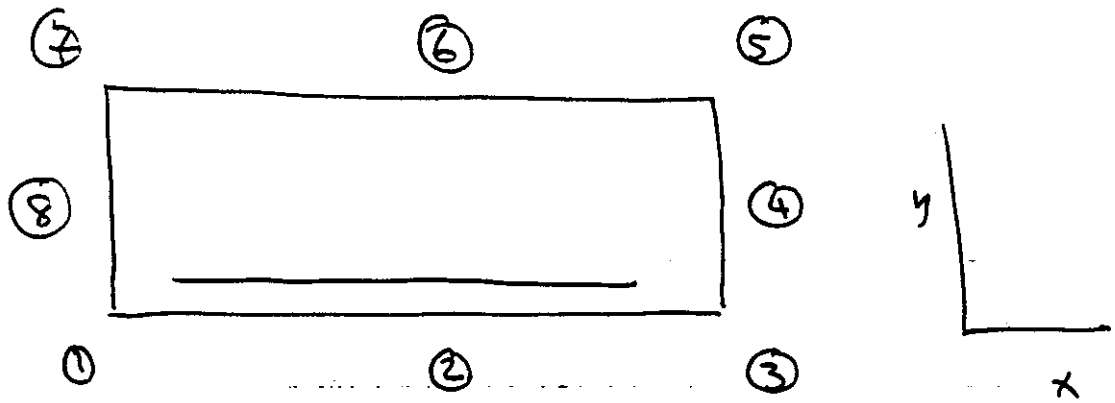
Prototype

Goal : build a ~~2m x 1m~~ 0.5m x 1.0m prototype and measure its properties (σ, ...)



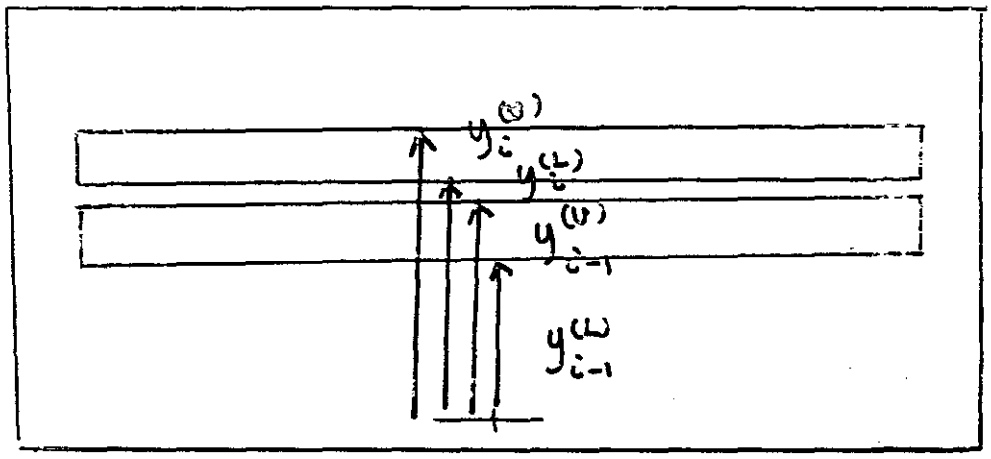

12.00 mm ± 0.025
12.00 mm ± 0.025
247.5 mm ± 0.025
495.00 mm ±0.025
Fiducial Mark
20.00 mm± 0.13
4.00 mm± 0.025
1.00 mm± 0.035
10.00 mm ± 0.025
10.00 mm± 0.025
10.00 mm ± 0.025
Copper
22.00 mm ± 0.13
22.00 mm ± 0.13
510.00 mm ±0.025
1000 mm ± 0.025
510.00 mm ±0.025
1040 mm ± 0.15
12.00 mm ± 0.025
12.00 mm ± 0.025
10.00 mm ±0.025
1
2
3
49
50
51
99
100
10.00 mm ± 0.025
10.00 mm ± 0.025
20.00 mm± 0.13
247.5 mm ± 0.025
495.00 mm ±0.025
539 mm ± 0.15
12.00 mm ± 0.025
12.00 mm± 0.025
Center line of strip no.1
Center line of strip no. 100
SCARF UH
SSC-GEM-FM-SB
05CU062FR4
4/4/92 - 2

Fiducial Marks



Board 1

FM	x_{ob}	x_{th}	Δx	y_{ob}	y_{th}	Δy
1	0	0	0	0	0	0
2	20.0780	20.0787	-0.0007	0	0	0
3.	40.1539	40.1575	-0.0036	0.0012	0	0.0012
4	40.1528	40.1575	-0.0047	10.2159	10.2165	-0.0006
5	40.1504	40.1575	-0.0071	20.4315	20.4331	-0.0016
6	20.0746	20.0787	-0.0041	20.4307	20.4331	-0.0024
7	-0.0024	0	-0.0024	20.4309	20.4331	-0.0022
8	-0.0004	0	-0.0004	10.2154	10.2165	-0.0011
1	0.0004	0	0.0004	-0.0002	0	-0.0002



Strip width $W_i = y_i^{(U)} - y_i^{(L)}$

gap width $g_{i-1} = y_i^{(L)} - y_{i-1}^{(U)}$

Strip center $C_i = (y_i^{(U)} + y_i^{(L)})/2$

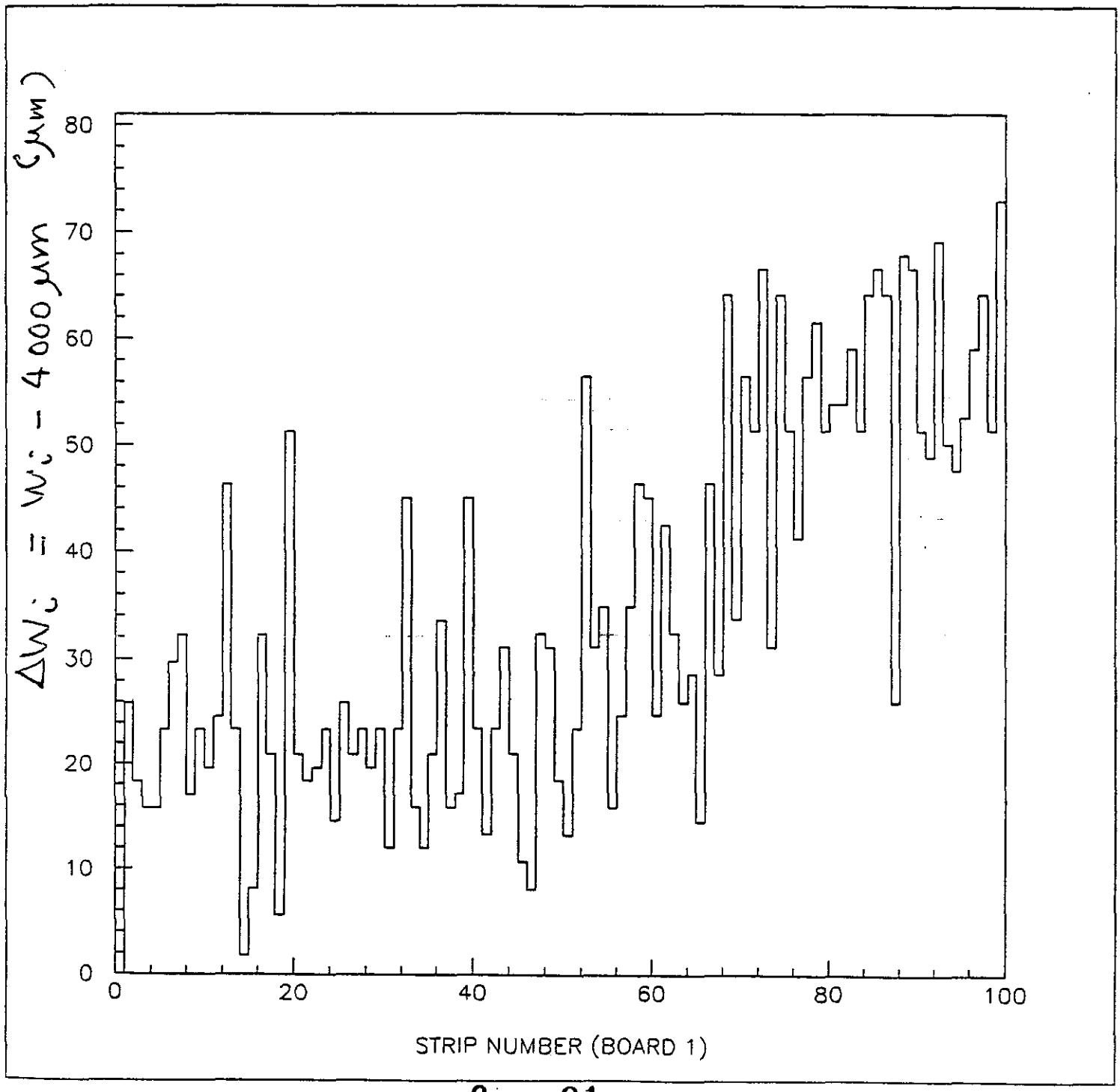
pitch $p_i = C_i - C_{i-1}$

$\Delta W_i = W_i - 4000.\ \mu m$

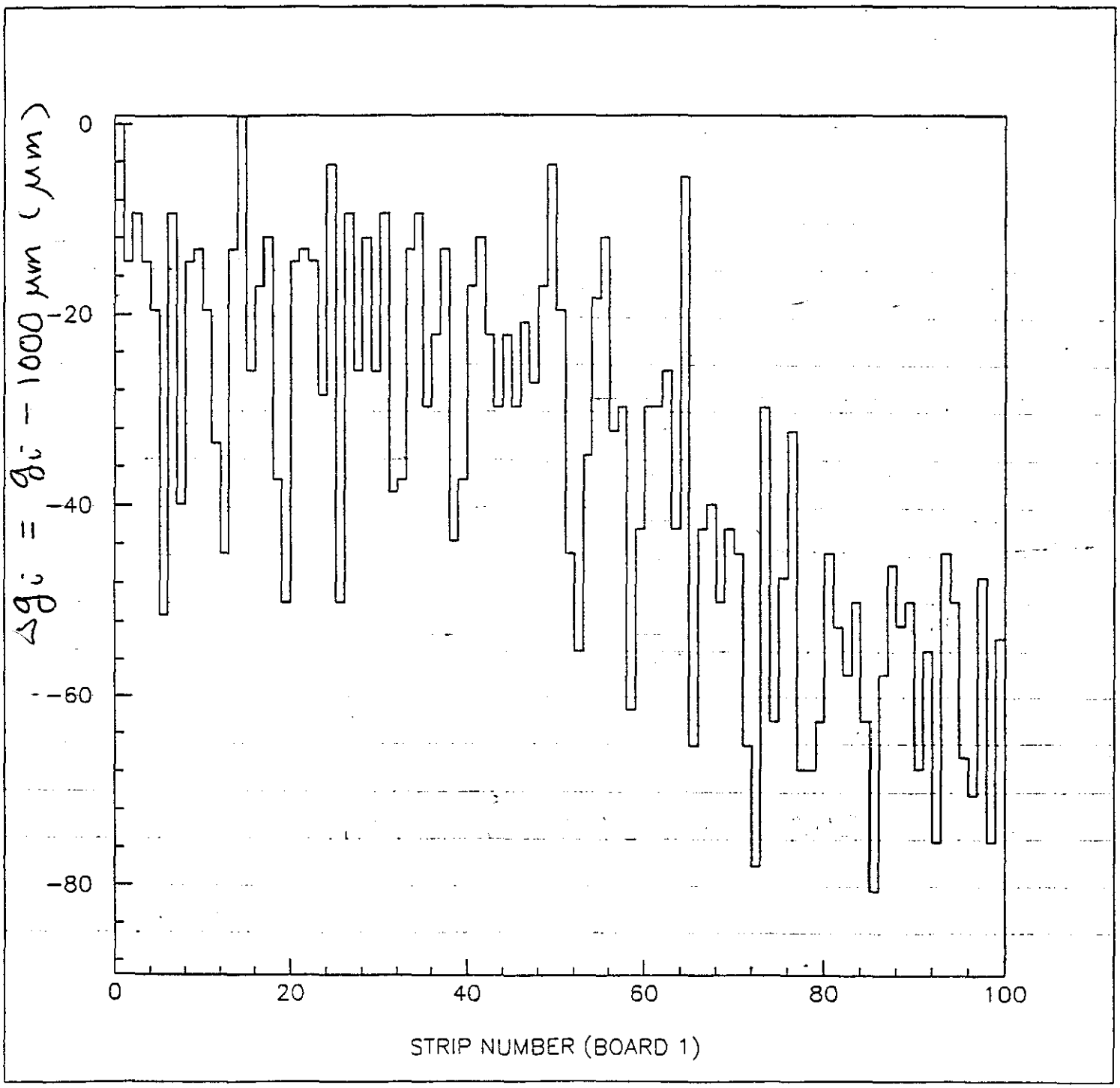
$\Delta g_i = g_i - 1000.\ \mu m$

$\Delta p_i = p_i - 5000\ \mu m$

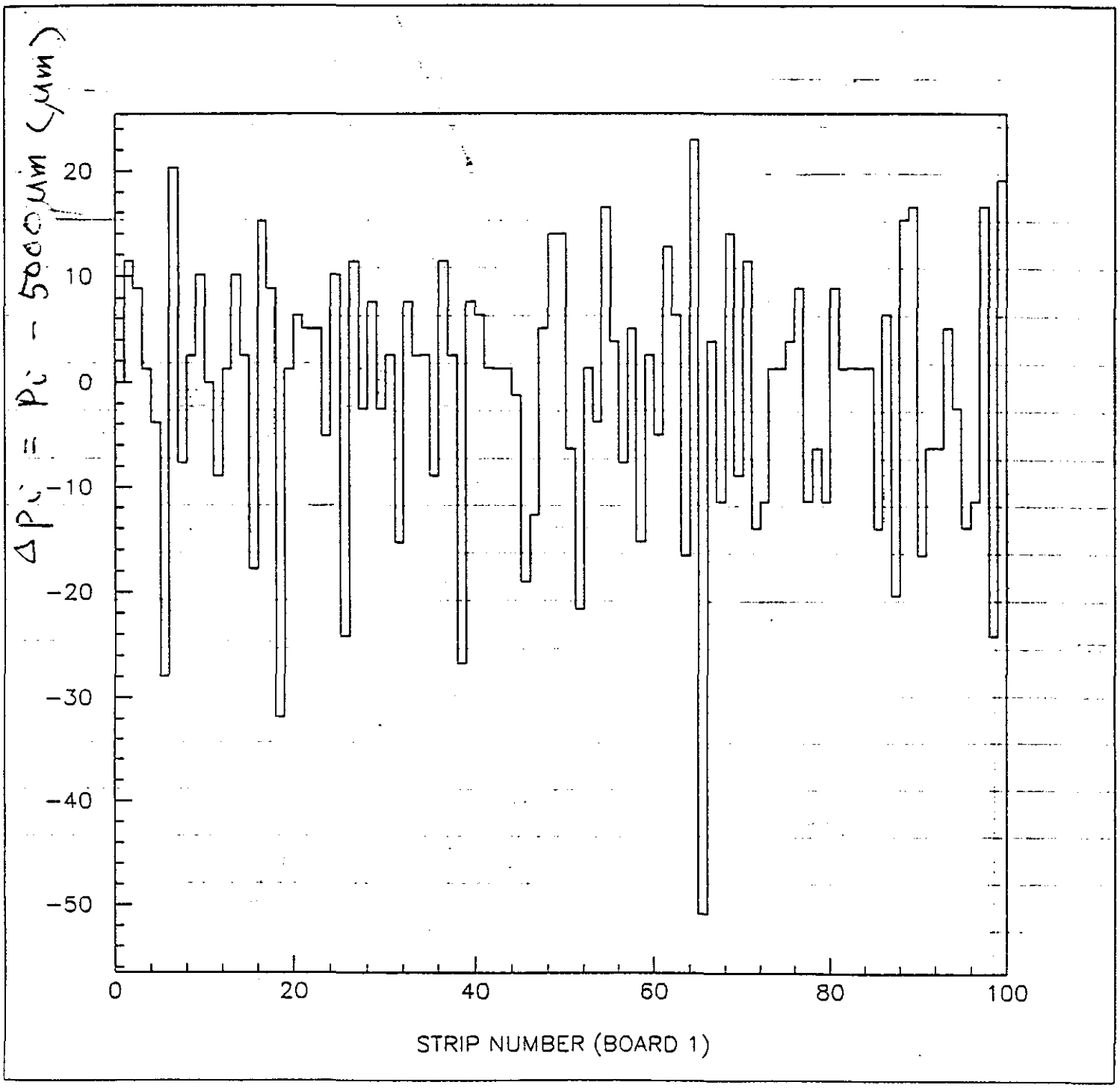
STRIP WIDTH ERROR

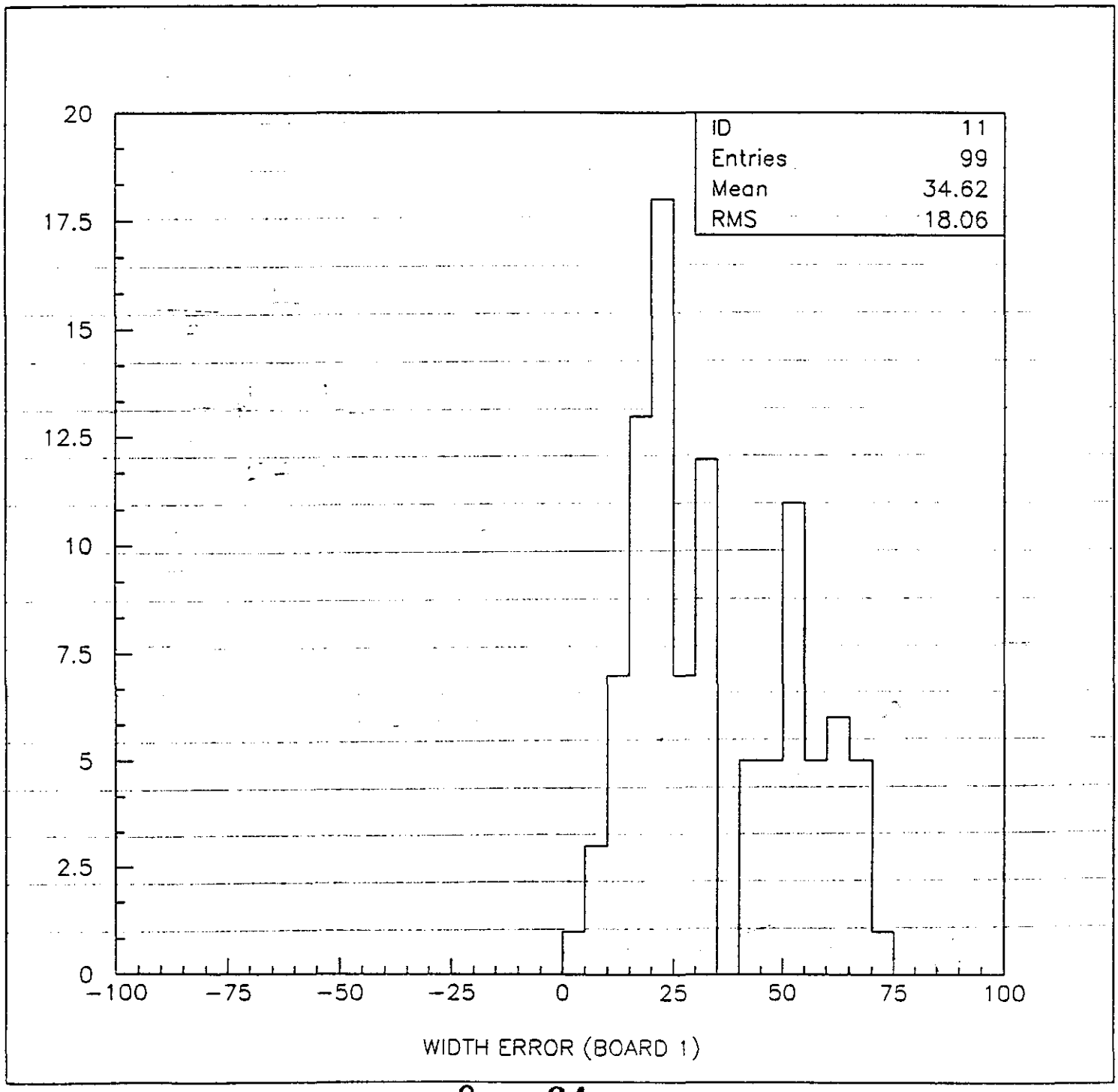


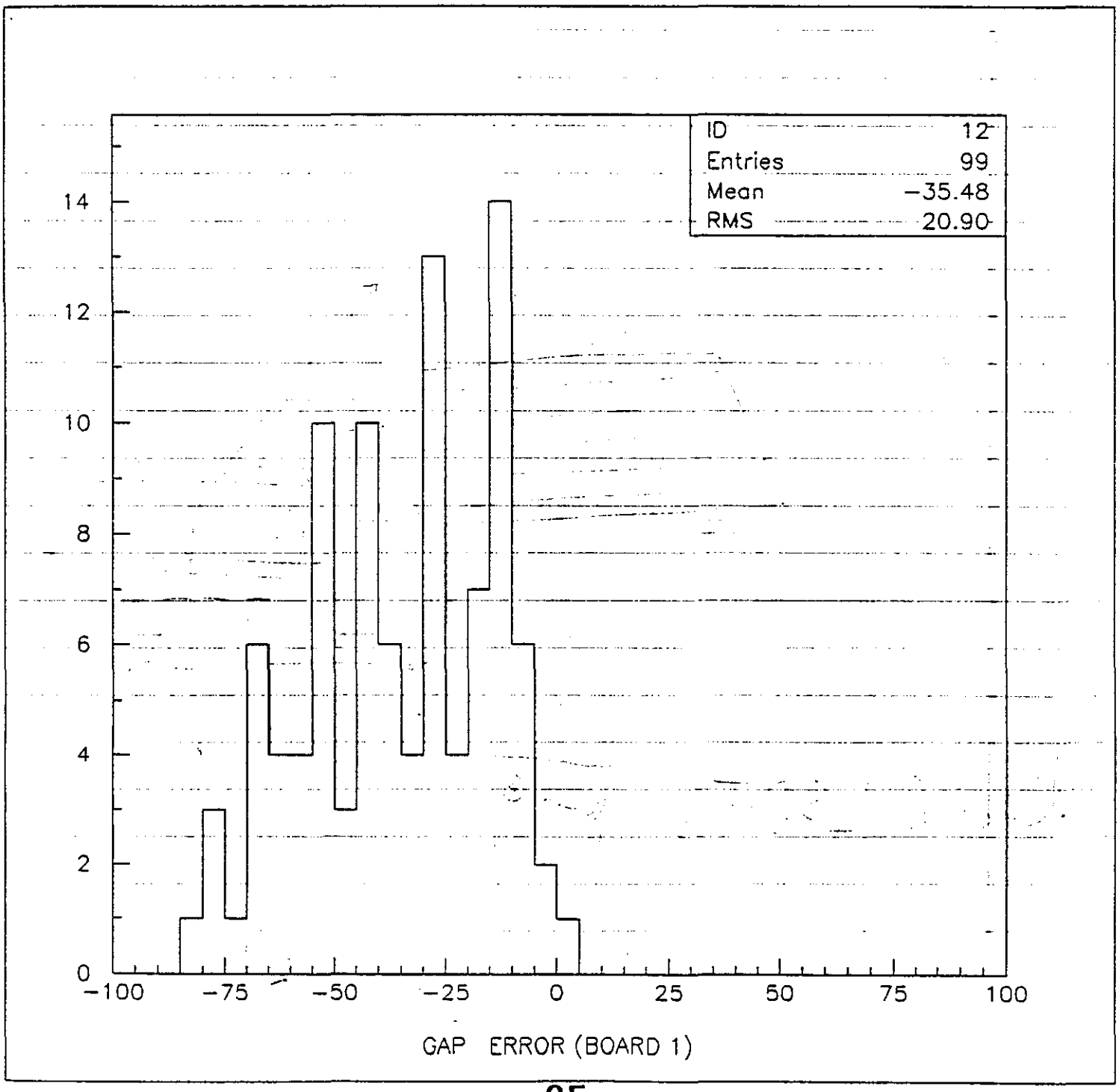
TAP WIDTH ERROR

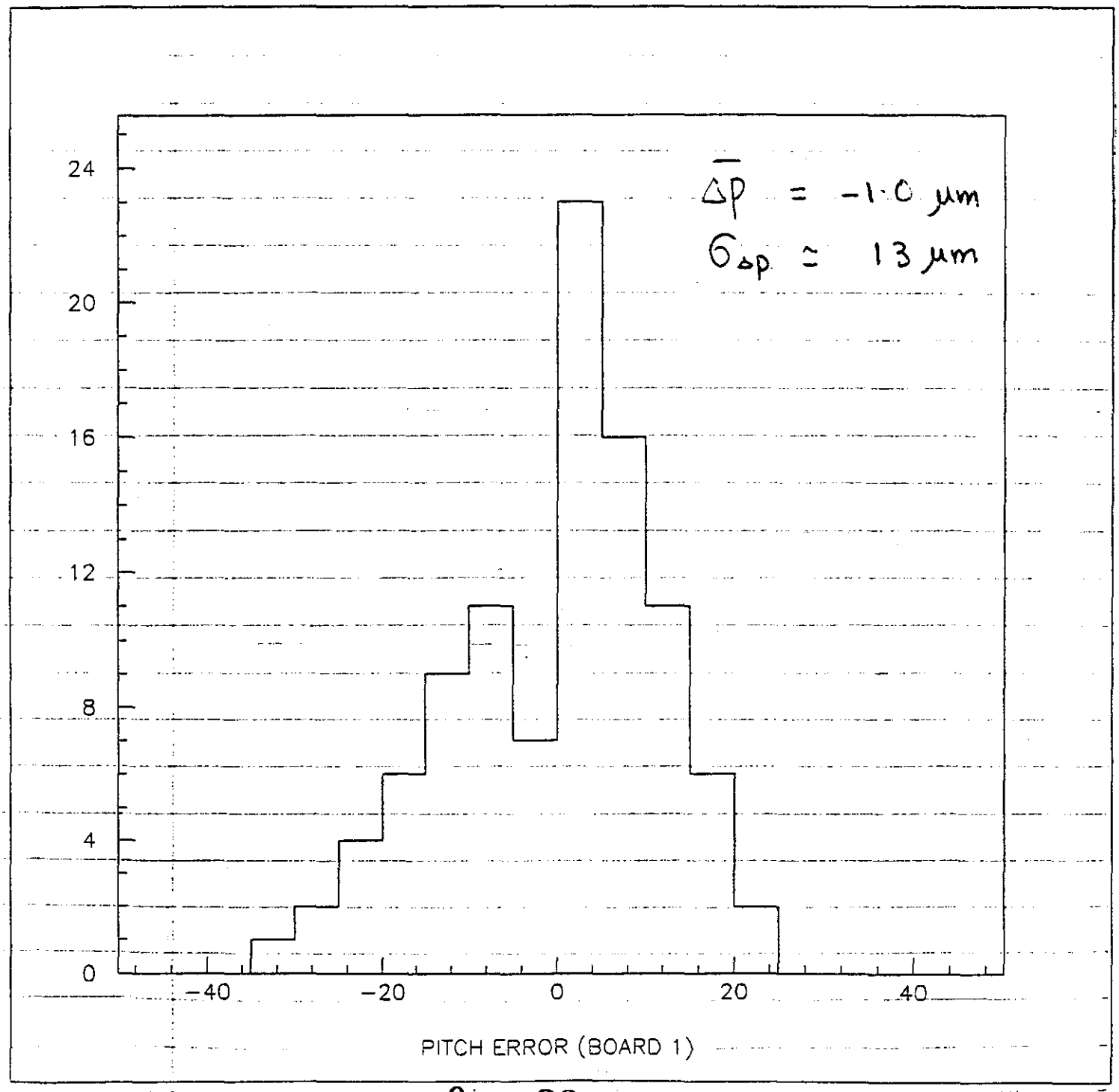


PITCH ERROR


$\Delta P_i = P_i - 5000\mu m$ (μm)
20
10
0
−10
−20
−30
−40
−50
0
20
40
60
80
100
STRIP NUMBER (BOARD 1)

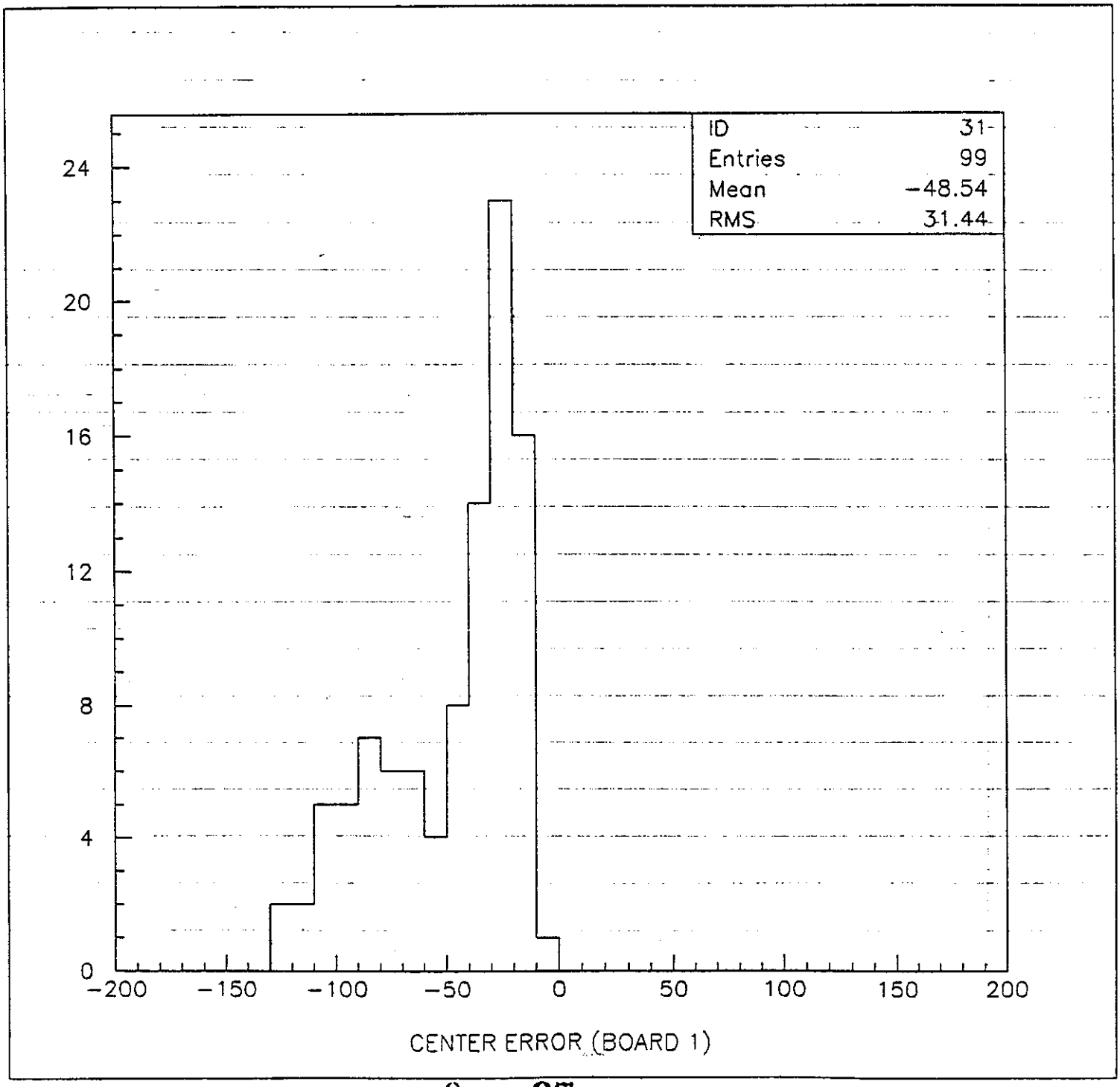

ID 11
Entries 99
Mean 34.62
RMS 18.06
20
17.5
15
12.5
10
7.5
5
2.5
0
−100
−75
−50
−25
0
25
50
75
100
WIDTH ERROR (BOARD 1)


ID 12
Entries 99
Mean −35.48
RMS 20.90
14
12
10
8
6
4
2
0
−100
−75
−50
−25
0
25
50
75
100
GAP ERROR (BOARD 1)


$\overline{\Delta p}$ = −1.0 μm
$\sigma_{\Delta p}$ ≃ 13 μm
24
20
16
12
8
4
0
−40
−20
0
20
40
PITCH ERROR (BOARD 1)

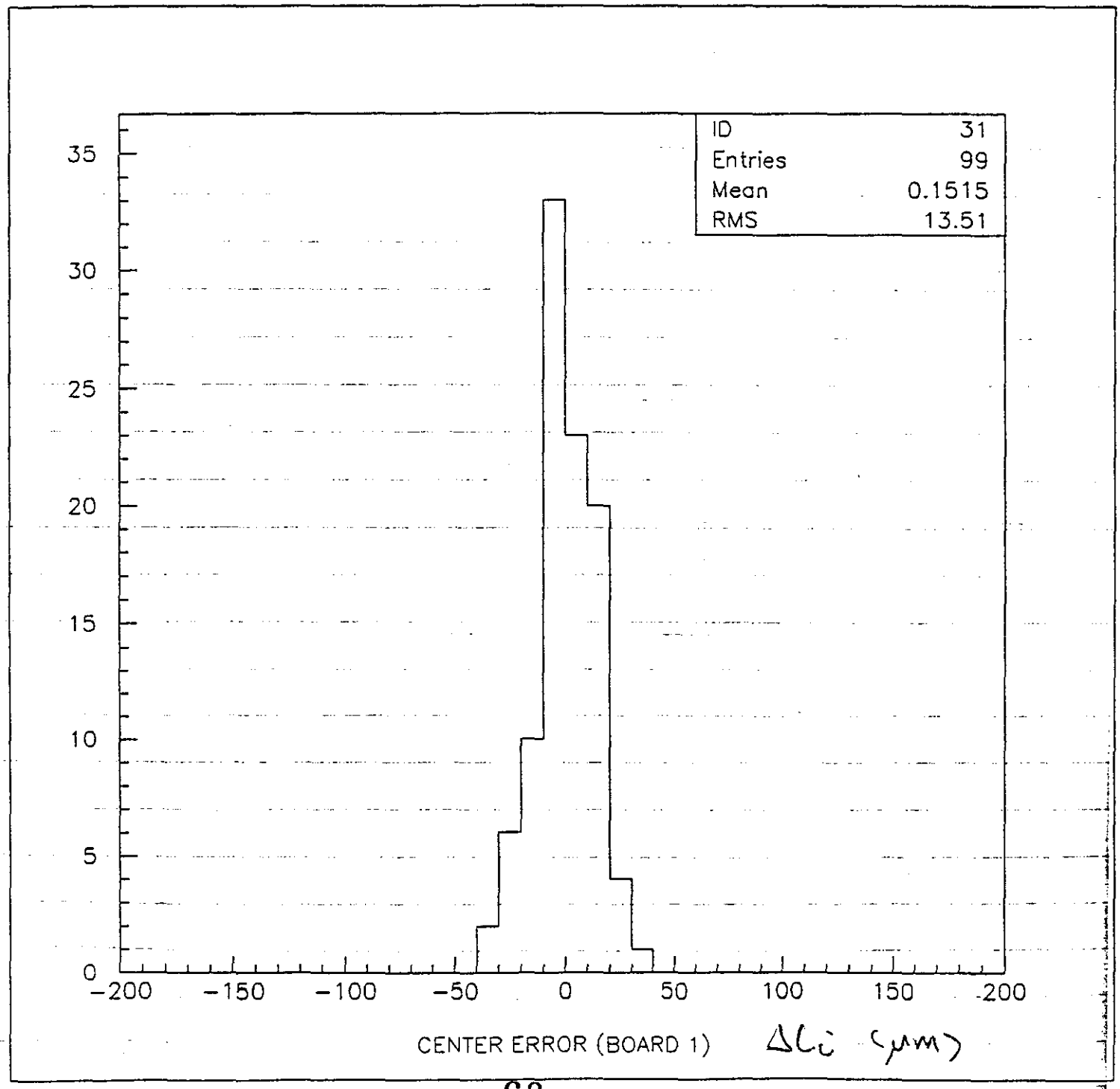
$$C_i^{th} = C_0 + i \times 5000\,\mu m$$

$$\Delta C_i = C_i - C_i^{th}$$

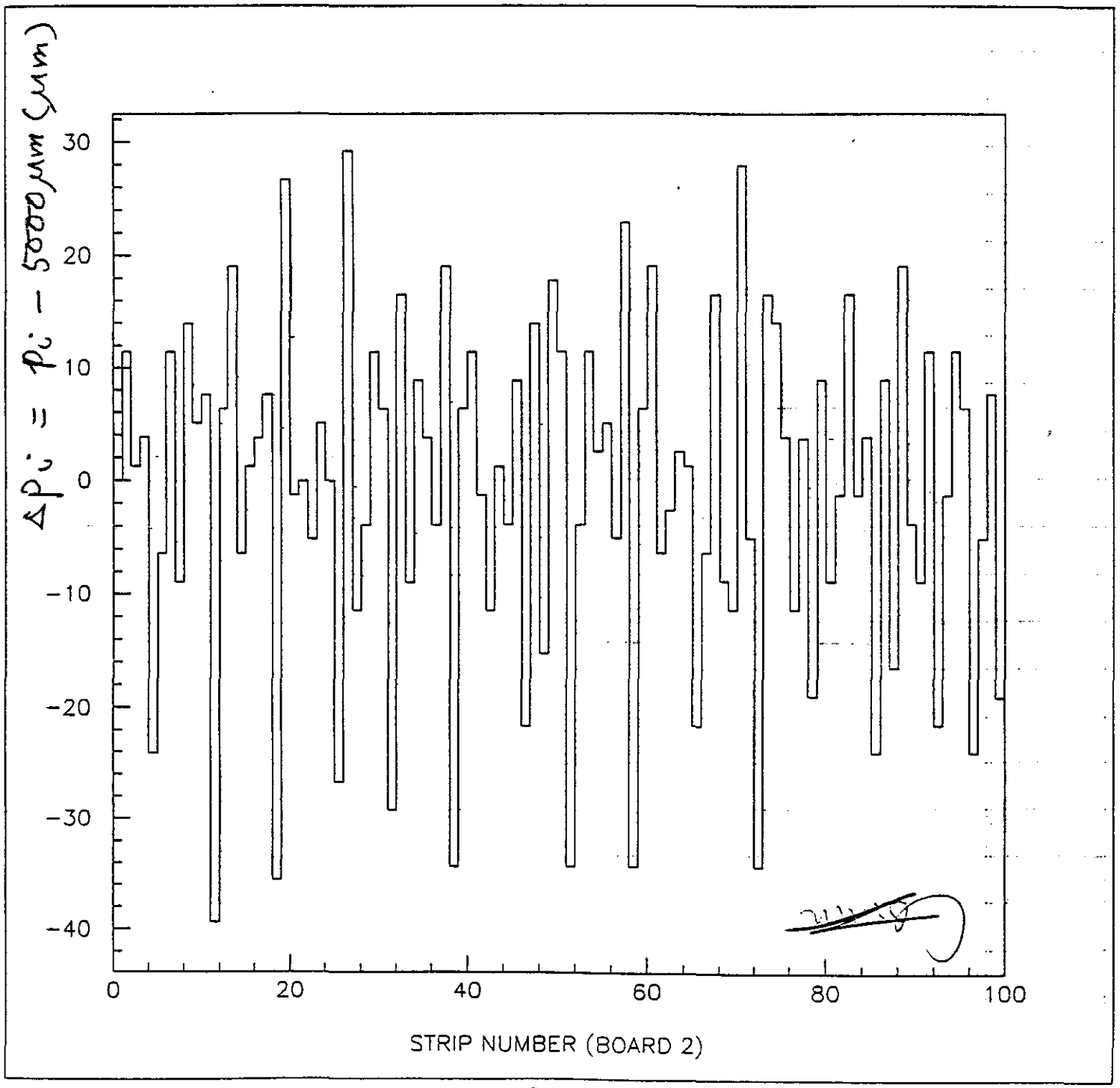


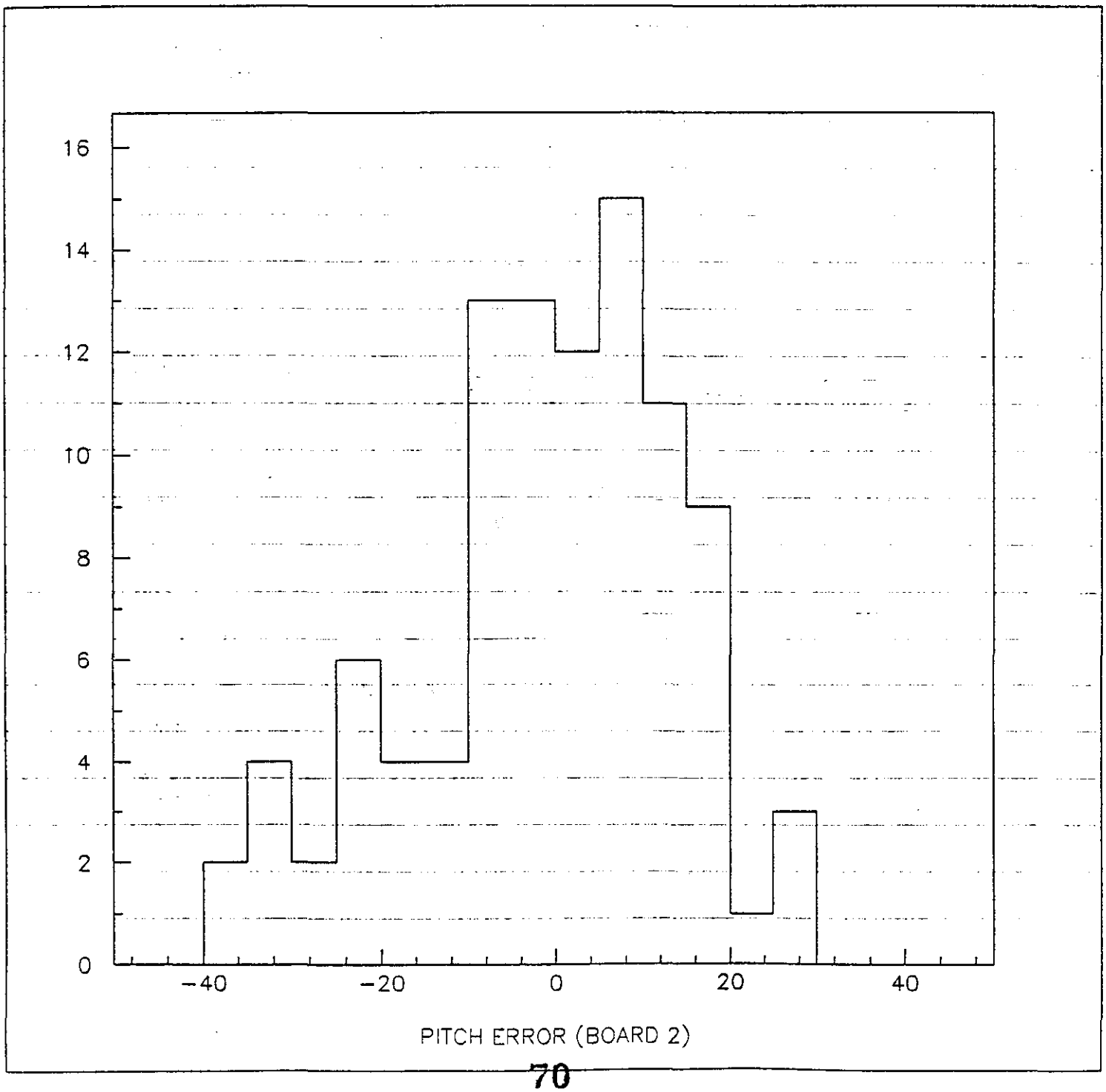
$$C_i^{th} = C_0 + i \times 4999.0\,\mu m$$

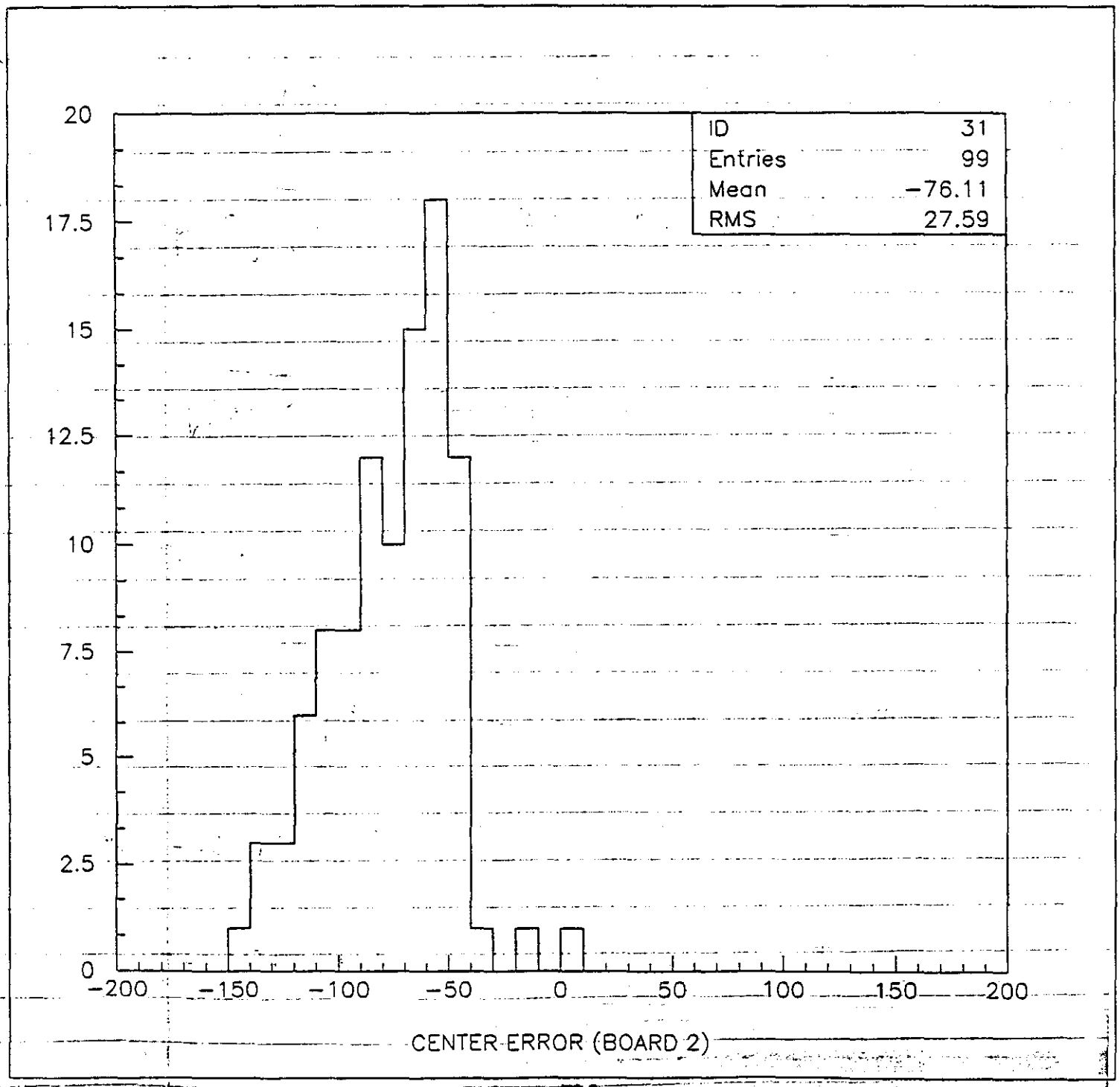
$$\Delta C_i = C_i - C_i^{th}$$

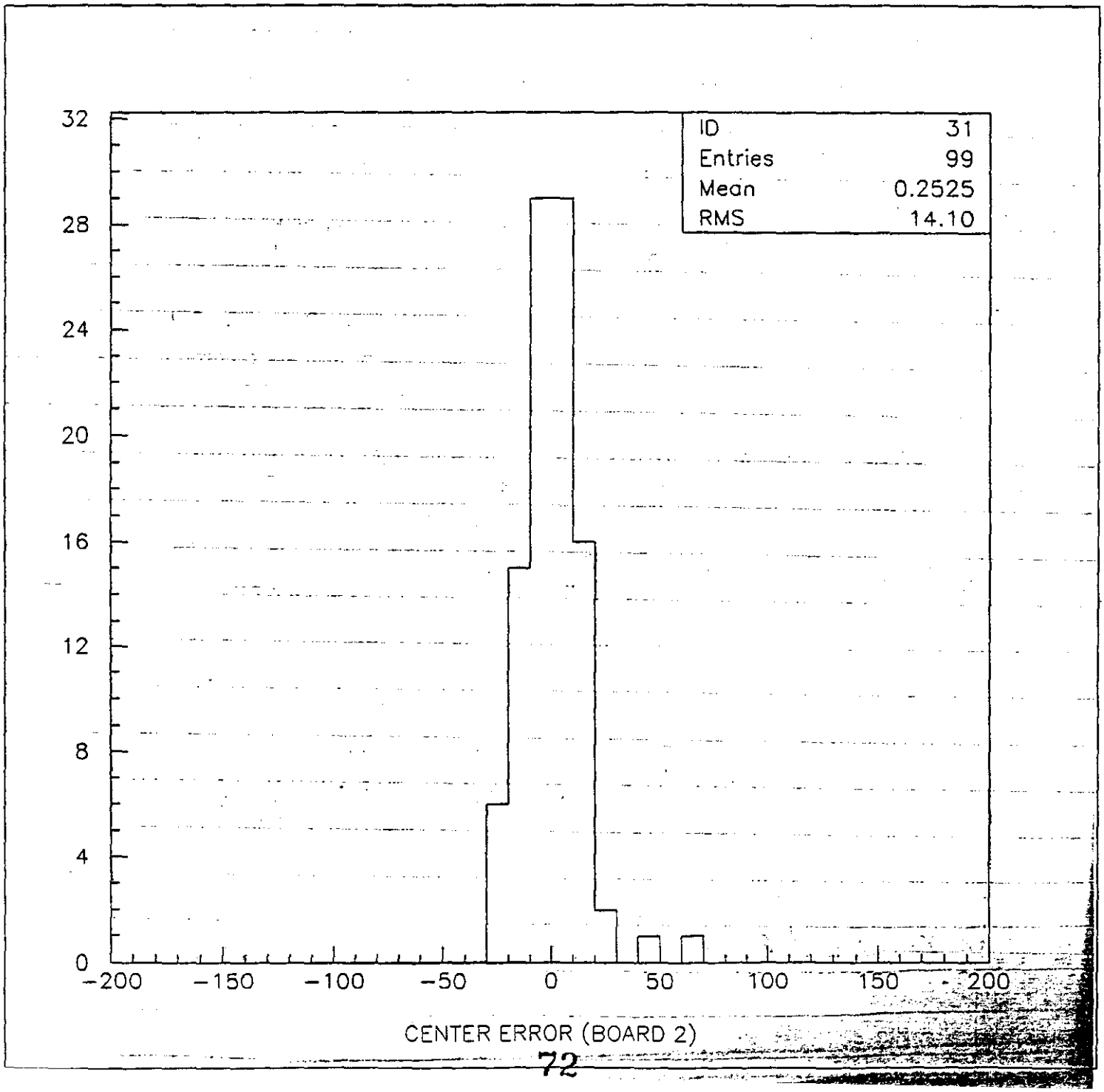


PITCH ERROR

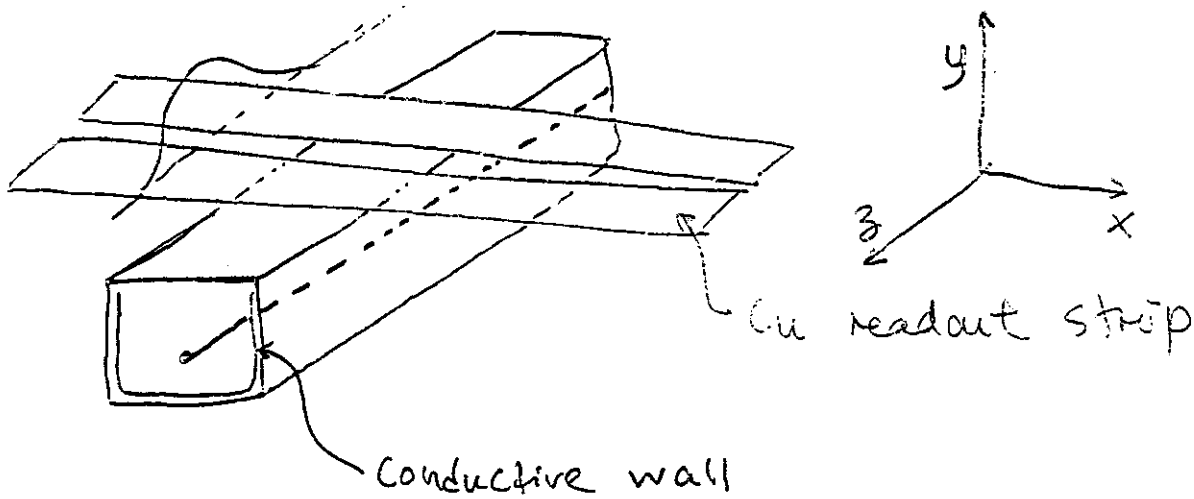

$\Delta p_i = p_i - 50000\,\mu m\ (\mu m)$
30
20
10
0
−10
−20
−30
−40
0
20
40
60
80
100
STRIP NUMBER (BOARD 2)

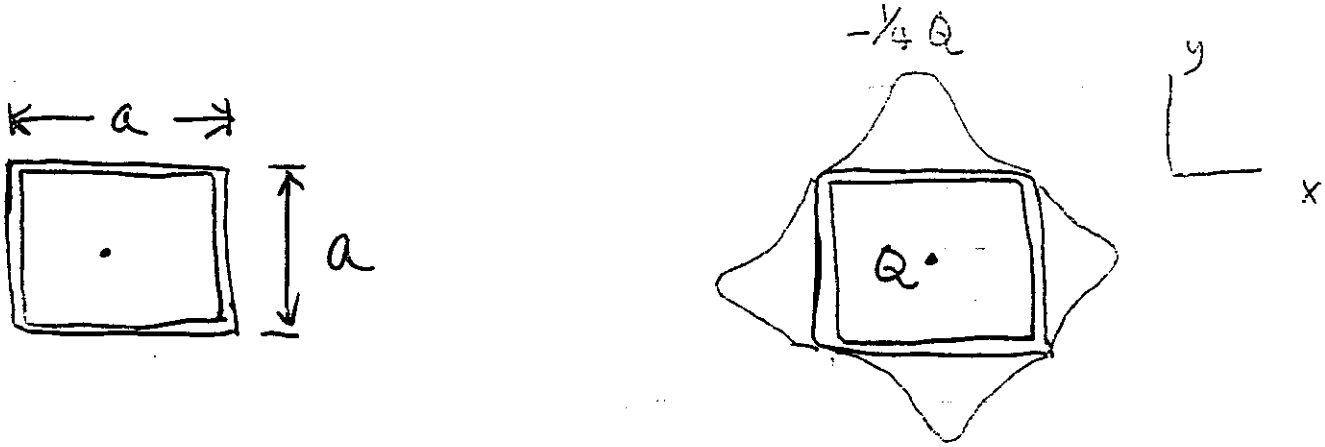

16
14
12
10
8
6
4
2
0
-40
-20
0
20
40
PITCH ERROR (BOARD 2)


ID 31
Entries 99
Mean −76.11
RMS 27.59
20
17.5
15
12.5
10
7.5
5
2.5
0
−200
−150
−100
−50
0
50
100
150
200
CENTER ERROR (BOARD 2)


ID 31
Entries 99
Mean 0.2525
RMS 14.10
32
28
24
20
16
12
8
4
0
−200
−150
−100
−50
0
50
100
150
200
CENTER ERROR (BOARD 2)

Induced Charge Calculation



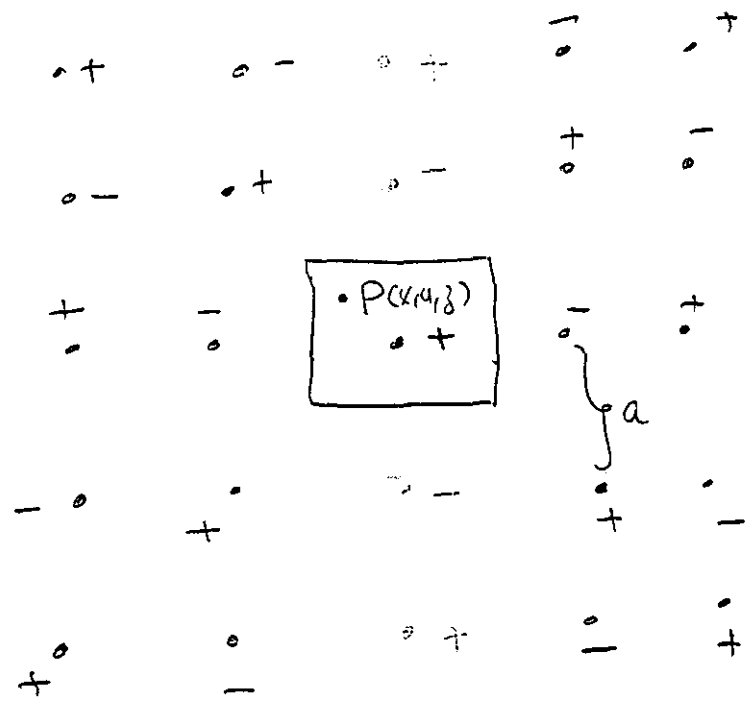


$$\frac{dQ_{induced}}{dz}(z) = \int_{-\frac{1}{2}a}^{\frac{1}{2}a} \sigma(x,z)\,dx$$

Charge induced on strip at z_0 to $z_0 + w$

$$Q_{induced} = \int_{z_0}^{z_0+w} \frac{dQ_{induced}}{dz} \cdot dz$$

Solution :



$$V(x,y,z) = \sum_{\substack{m=-N,N \\ n=-N,N}} V_{m,n}(x,y,z)$$

$$\sigma(x,z) = \epsilon_0 E_y \Big|_{y=\frac{1}{2}a} = \epsilon_0 \left(-\frac{\partial V}{\partial y}\right)\Big|_{y=-\frac{1}{2}a}$$

Grid of $(2N+1)^2$ point charges

$$\frac{dQ_{\text{induced}}}{d\bar{z}} = \frac{1}{4\pi}\cdot\frac{1}{2}\,\frac{1}{\left[\bar{z}^2+\frac{1}{4}\right]^{3/2}}\cdot\frac{1}{\sqrt{1+\dfrac{\frac{1}{4}}{\left[\bar{z}^2+\frac{1}{4}\right]}}}$$

$$+\frac{1}{4\pi}\sum_{n=1}^{N}(-1)^n\left\{\left(n+\tfrac{1}{2}\right)\frac{1}{\left[\bar{z}^2+\left(n+\frac{1}{2}\right)^2\right]^{3/2}}\,\frac{1}{\sqrt{1+\dfrac{\frac{1}{4}}{\left[\bar{z}^2+\left(n+\frac{1}{2}\right)^2\right]}}}\right.$$

$$\left.-\left(n-\tfrac{1}{2}\right)\frac{1}{\left[\bar{z}^2+\left(n-\frac{1}{2}\right)^2\right]^{3/2}}\,\frac{1}{\sqrt{1+\dfrac{\frac{1}{4}}{\left[\bar{z}^2+\left(n-\frac{1}{2}\right)^2\right]}}}\right\}$$

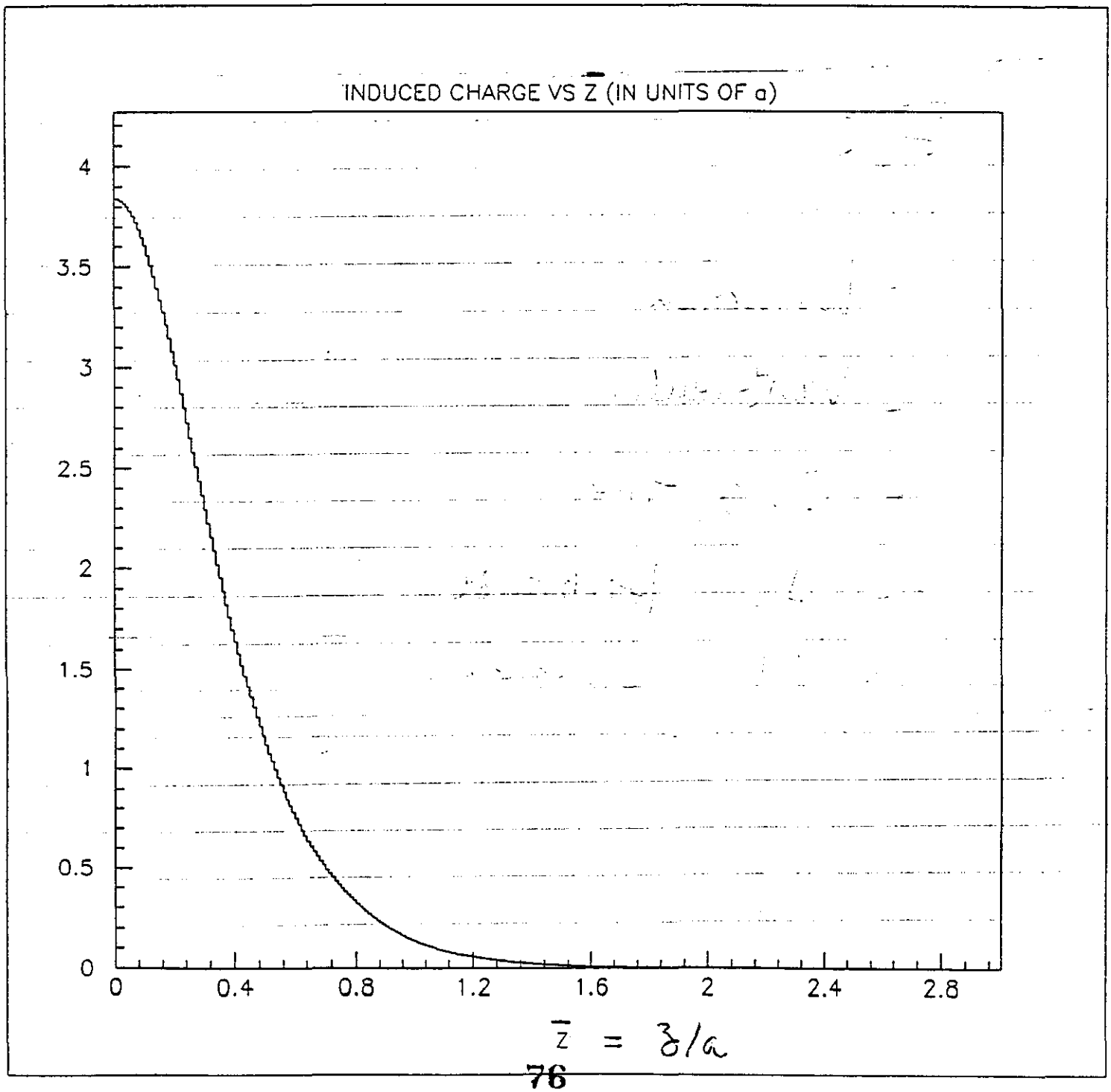
$$+\frac{1}{4\pi}\sum_{k=1}^{N}(-1)^k\frac{1}{\left[\bar{z}^2+\frac{1}{4}\right]^{3/2}}\left\{\frac{\left(k+\frac{1}{2}\right)}{\sqrt{1+\dfrac{\left(k+\frac{1}{2}\right)^2}{\left[\bar{z}^2+\frac{1}{4}\right]}}}-\frac{\left(k-\frac{1}{2}\right)}{\sqrt{1+\dfrac{\left(k-\frac{1}{2}\right)^2}{\left(\bar{z}^2+\frac{1}{4}\right)}}}\right\}$$

$$+\frac{1}{4\pi}\times 2\times\sum_{\substack{m=1,N\\ n=1,N}}(-1)^{m+n}\left\{\frac{\left(n+\frac{1}{2}\right)}{\left[\bar{z}^2+\left(n+\frac{1}{2}\right)^2\right]^{3/2}}\left[\frac{\left(m+\frac{1}{2}\right)}{\sqrt{1+\dfrac{\left(m+\frac{1}{2}\right)^2}{\bar{z}^2+\left(n+\frac{1}{2}\right)^2}}}-\frac{\left(m-\frac{1}{2}\right)}{\sqrt{1+\dfrac{\left(m-\frac{1}{2}\right)^2}{\bar{z}^2+\left(n+\frac{1}{2}\right)^2}}}\right]\right.$$

$$\left.-\frac{\left(n-\frac{1}{2}\right)}{\left[\bar{z}^2+\left(n-\frac{1}{2}\right)^2\right]^{3/2}}\left[\frac{\left(m+\frac{1}{2}\right)}{\sqrt{1+\dfrac{\left(m+\frac{1}{2}\right)^2}{\bar{z}^2+\left(n-\frac{1}{2}\right)^2}}}-\frac{\left(m-\frac{1}{2}\right)}{\sqrt{1+\dfrac{\left(m-\frac{1}{2}\right)^2}{\bar{z}^2+\left(n-\frac{1}{2}\right)^2}}}\right]\right\}$$

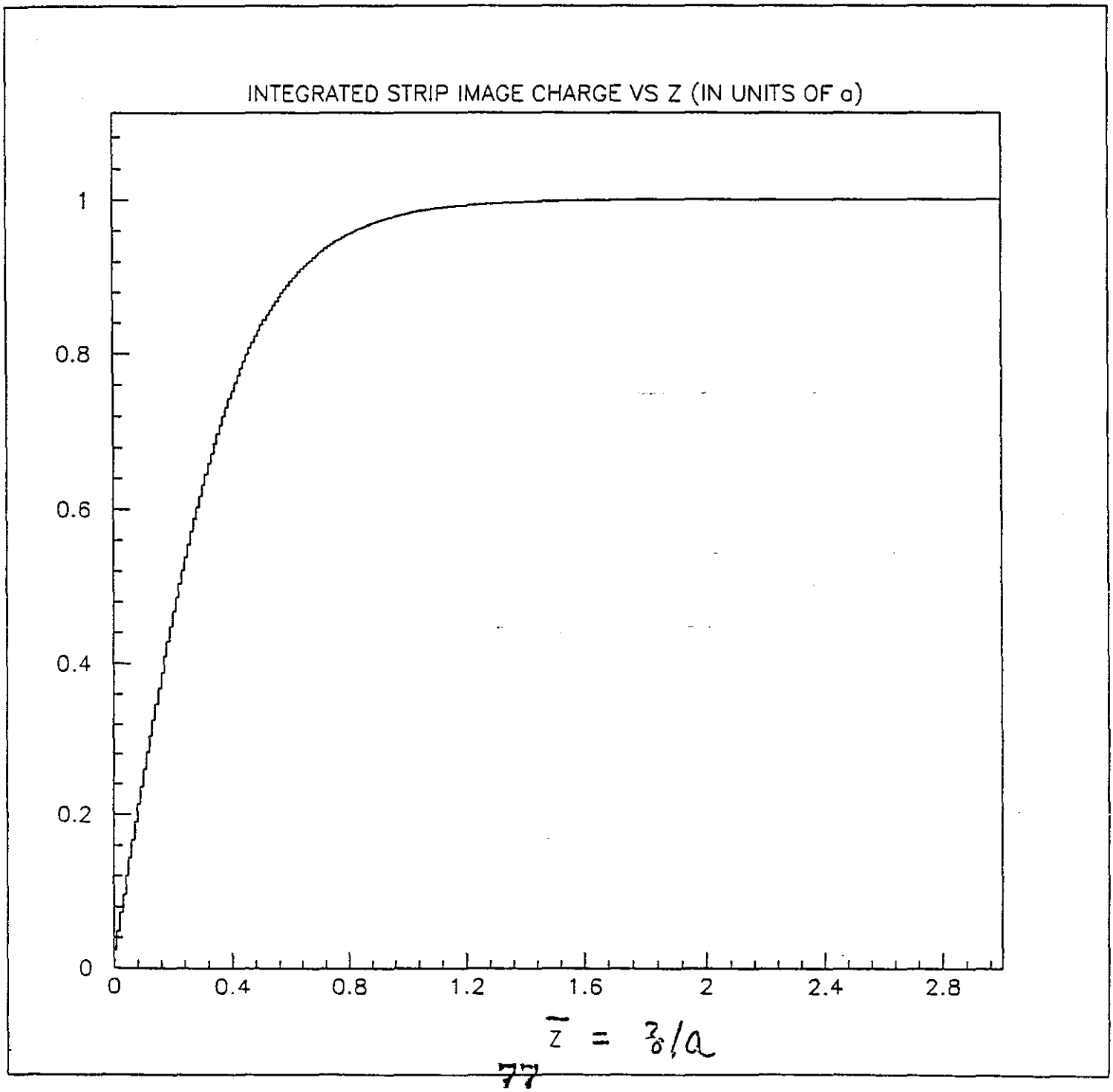
$$\frac{dQ_{induced}(\bar{z})}{d\bar{z}}$$

$\bar{z} > 0$



$$\int_0^{\bar{z}} \frac{dQ_{induced}}{d\bar{z}'}(\bar{z}')\, d\bar{z}'$$

$\bar{z} > 0$

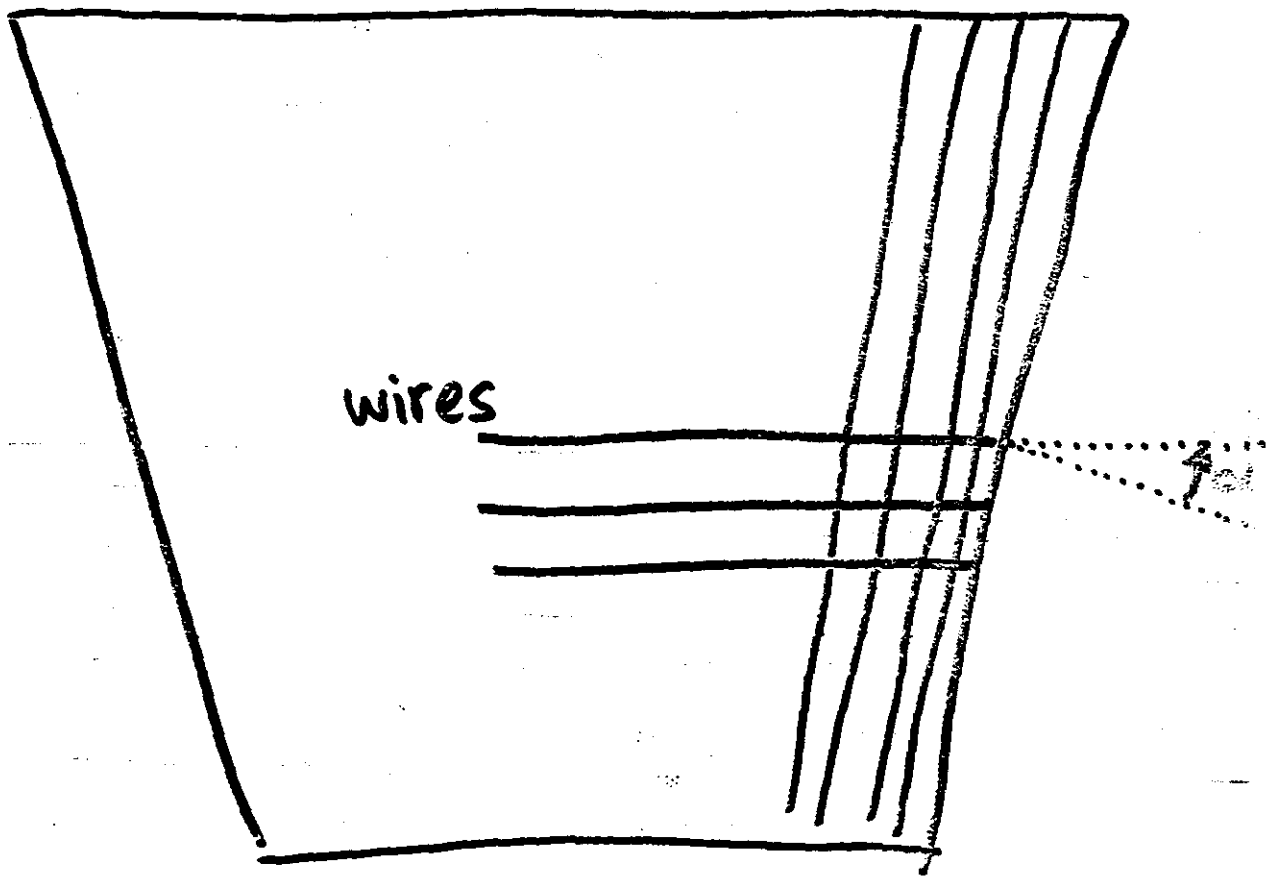


ERRORS IN CSC

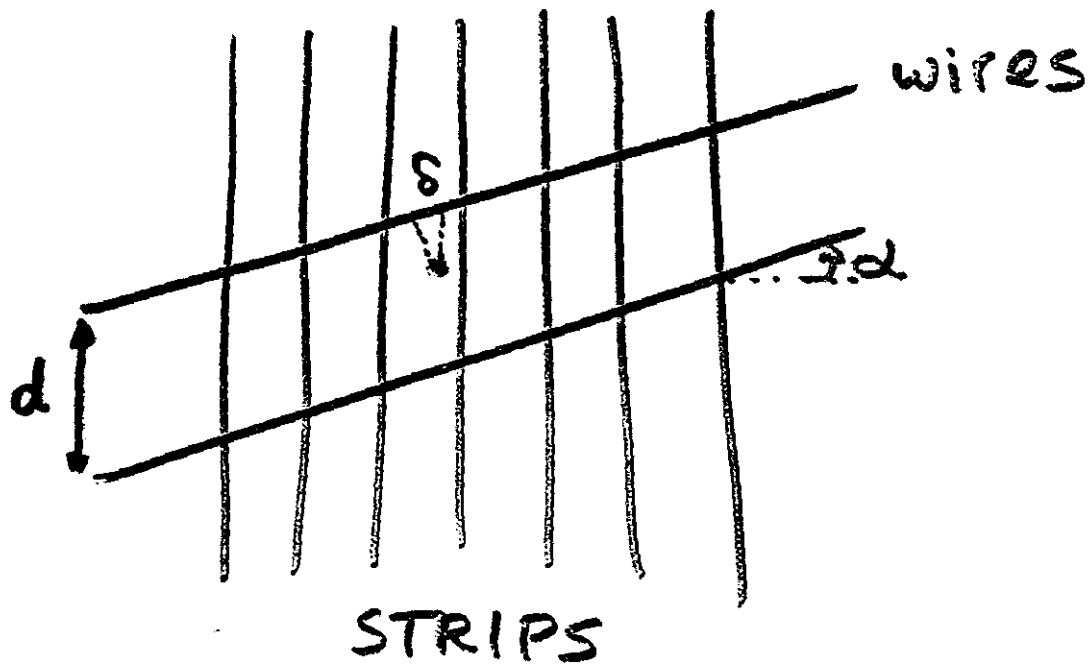
GENA MITSELMAKHER

G. Mitselmakher A. Kotov 03/03/92

GEOMETRICAL ERROR in CSC due to angle α



1. Origins of the ERROR



$d = 2.5\,\text{mm}$
$\alpha = 11^\circ$
$\sin\alpha \sim \frac{1}{5}$

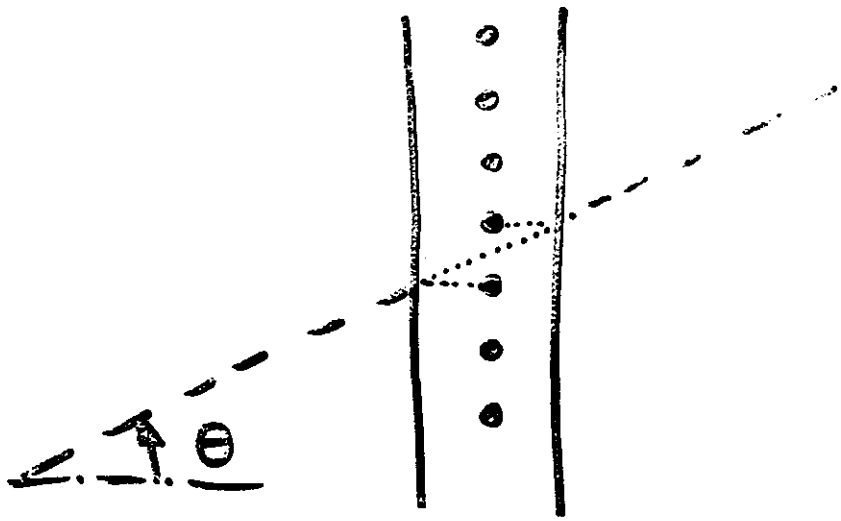
$$\delta = \frac{d}{2}\sin\alpha \sim 250\,\mu\text{m}$$

*! You have to align wires in y-direction within ~ 200 μm
(200μm/5 << 75μm)

* No such error when $\alpha = 0^\circ$

2) REAL LIFE:

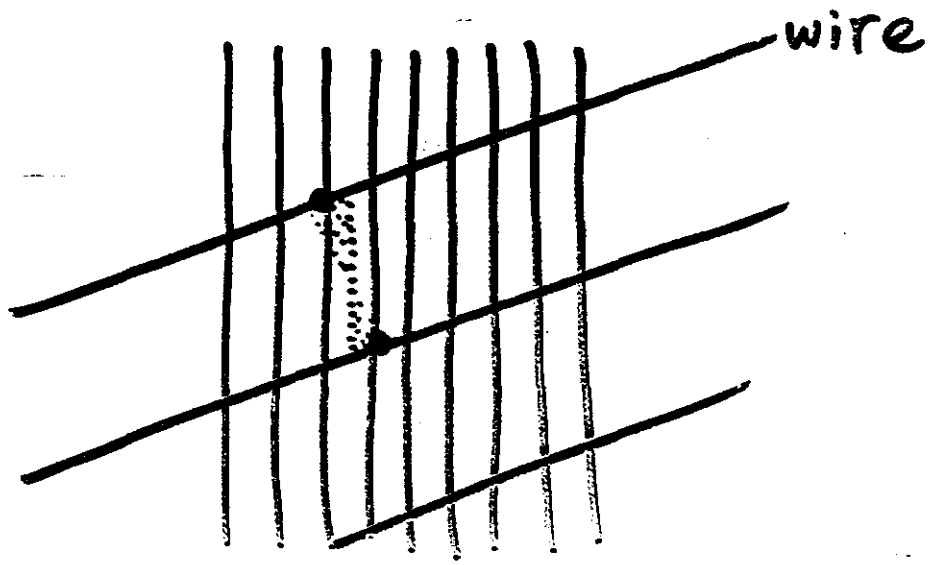
A)

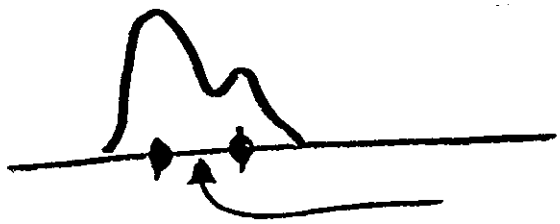


Quite often TWO hits!

For $\theta = 30°$, 100%

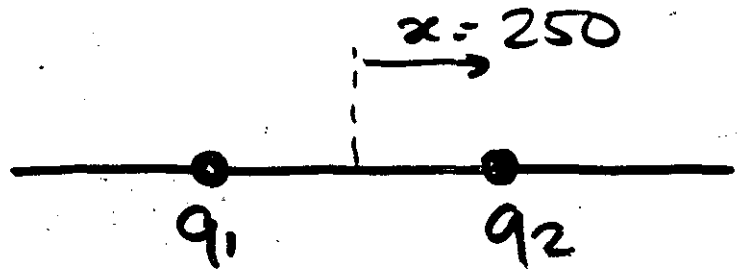
B)





$\alpha = 10°$

$\Delta = 150\ \mu m$



$$COG = \frac{-q_1 + q_2}{q_1 + q_2} \cdot x$$

$$\delta COG \simeq \frac{\delta q}{\sqrt{2}\, q} \cdot x \sim \frac{\delta q}{q} \cdot 180\,\mu m$$

$$\frac{\delta q}{q} \sim 80\%$$

$$\delta\, COG \sim 150\,\mu m \quad (\text{for } \alpha = 10^\circ)$$

to keep $\delta < 50\,\mu m$, $\alpha < 3^\circ$

RPC STATUS

Craig Wuest

RPC R+D Status

- 1x1 m² RPC from Phase II @ MIT
  - time jitter ± 1.5 ns
- E ≈ 95% @ 6.5 kV
- Materials under study
  - Glass
  - Bakelite - Westinghouse
  - Cermet - Ta or Cr
- ME of RPC beginning
  - visit to Draper, MIT
- FY 93 R+D Plan formulated
  submitted to GEM (B. Webb)
- Costing
- EE support in FY 93

Table 1. GEM RPC Chamber Specifications

Coverage: 100% - Z, 95% Phi
Areal Mass: Bakelite - 6.4% Xo (0.02" Al-skinned hexcel gas box)
Bakelite - 3.4% Xo (no gas box)
Cermet - 3.9% Xo (0.02" Al-skinned hexcel gas box)
Cermet - 1.0% Xo (no gas box)

Nominal Radius (m):	4.0	6.0	8.0
# of chambers:	64	96	128
Width (cm):	148.5	239.0	329.6
Length (cm):	330.0	360.0	380.0
Total Length (cm): (half sector)	631.9	1042.1	1475.0
Thickness (cm):			
Bakelite:	5.0	5.0	5.0
Cermet:	3.0	3.0	3.0
# bend-plane strips:	114	183	253
# non-bend-plane strips:	166	166	166
Width of bend-plane strips(cm):	1.3	1.3	1.3
Width of non-bend-plane strips:	3.9	6.5	8.9
Weights: (lbs)			
RPC + gas enclosure:			
Bakelite:	16224	44992	88000
Cermet:	9670	25920	50976
RPC w/o gas enclosure:			
Bakelite:	9384	24713	47967
Cermet:	2160	5688	11039
Aluminum perimeter frame:	1049	1472	2304
Carbon composite frame:	800	1728	6720
Cable:	385	641	963
Connecters, brackets, etc.:	1160	2855	5795
Total Weight/superlayer (lb):			
Bakelite (no gas box):	12778	31409	63749
Cermet (no gas box):	5554	12384	26821

TOTAL WEIGHT (tons): BAKELITE: 54.0 CERMET: 22.4

From: IGW::MITLNS::PLESS 24-JUN-1992 11:44:10.63
To: @SRPC.DIS
CC:
Subj: PROPOSED LETTER TO WEBB ON R&D FUNDING

Dear Bob,

The purpose of this note is to give you a very rough idea of The RPC group's plans for our FY 93 R&D program. We also summarise the accomplishments of the FY 92 R&D program.

I. Results of the FY 92 R&D program utilising the 1 meter by 2 meter Italian bakelite RPC.

A. Efficiency > 95%
B. Rise time < 1 nanosecond
C. Rise time jitter < 1.4 nanosecond
D. Repetition rate about 100 hertz
E. Radiation length < 3% per superlayer
F. Neutron sensitivity < 0.005 per neutron

II. R&D objectives for FY 93

A. Develope fabication techniques for a 2 meter by 4 meter RPC
B. Reduce radiation length to < 1% per superlayer
C. Increase repetition rate to > 1,000 hertz
D. Maintain efficiency > 95%, rise time < 1 nanosecond, rise time jitter < 1.4 nanoseconds

LLNL will have the responsibility for developing the fabrication techniques for a 2 meter by 4 meter RPC. In addition, LLNL will have the responsibility for the support scheme for this device and integrating it into the GEM structure.

Brown, Indiana, MIT, and Tennessee wil be responsible for reducing the radiation length, and increasing the repetition rate. This will be done by construction about 10 RPC's each about 1 meter by 1 meter using various materials. We now have enough experience to know what materials to test to achieve the goals of this R&D program.

III. LLNL R&D program

A. Determine sources or techniques to obtain large sheets of bakelite (2 meters by 4 meters) of minimum thickness (less than 1 millimeter)
B. Determine techniques to coat large areas of thin bakelite with aquadag or other high resistive coatings
C. Determine techniques to laminate bakelite, aluminised mylar, and foam into a monolithic sheet 2 meters by 4 meters
D. Determine techniques to attach inner spacers and seal the edges of a 2 meter by 4 meter RPC.
E. Determine techniques to attach the high voltage to the RPC.
F. Determine techniques to take out the signals from the RPC readout strips
G. Determine techniques to support and transport the 2 meter by 4 meter RPC
H. Determine techniques to intergrate the 2 meter by 4 meter RPC into the Gem Detector

IV. Brown, Indiana, MIT, Tennessee R&D program

A. Aquire semiconducting Bakelite of various resistivities and thickness
   1. Resistivities from ten to the eigth to ten to to the tenth
   2. Thickness from 250 microns to 500 microns
B. Aquire suitable lacquers to coat bakelite
   1. Linseed oil
   2. Polyeurothane
   3. Acrylic polymers
   4. ETC.
C. Acquire suitable materials for spacers
   1. PVC
   2. Glass
   3. Teflon
   4. Ceramic
   5. ETC
D. Acquire suitable foam material for lamination
   1. Polystyrene
   2. PVC (rigid foam)
   3. ETC
E. Aquire suitable material for readout strips and ground

1. Brown 2
2. Indiana 2
3. MIT 4
4. Tennessee 2

G. Test 10 RPCs 1 meter by 1 meter
1. Tests will be done in the RPC test bed located at MIT by personell at the 4 Universities

V. Budgets

A. LLNL

1. Full time Mech Eng	$170k
2. Full time Tech	$ 80k
3. Full time Designer Draftsman	$ 80k
4. Materials	$ 50k
TOTAL	$380K

B. Brown, Indiana, MIT, Tennessee

1. Full time Engineer	$170k
2. Full time Technician	$ 80k
3. Materials	$100k
4. Electronics	$ 50k
TOTAL	$400k

We will obviously break down our budget into a more detailed need for the funds, but this should give you a first order feeling for our needs. If there are any questions, please contact me.

Sincerely yours,

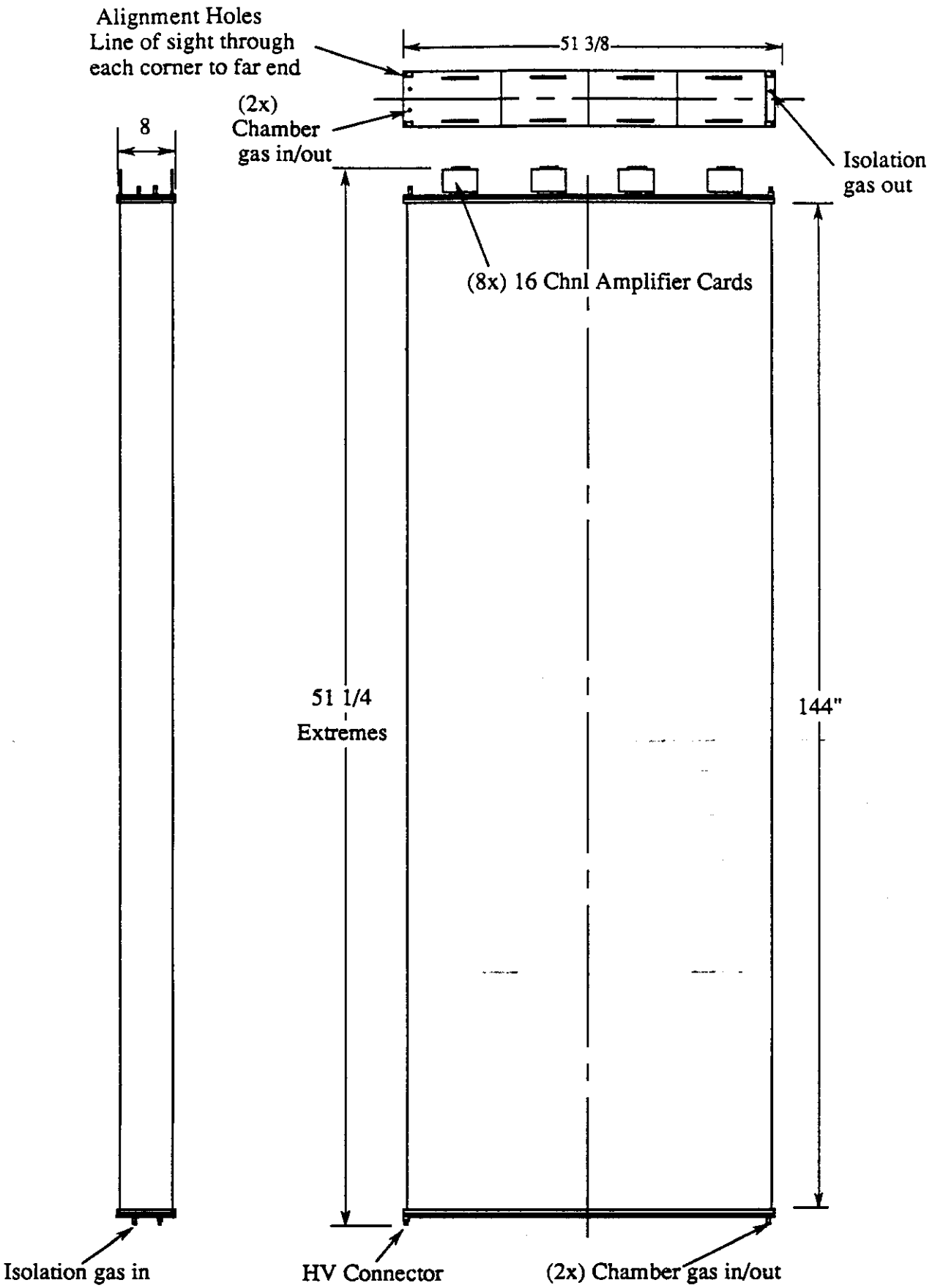
Irwin A. Pless

Radial Drift Chamber R+D

- 1m prototype constructed @ LANL
- Contract being written to MIT/L.L. for 1.27 m prototype using LSDT-style channels
- Gas box for 1.27 m prototype to be built @ LANL using LSDT mil plate / p.c. board format

STATUS OF PDT EFFORT

Bob Miller



GEM PDT Prototype Assembly

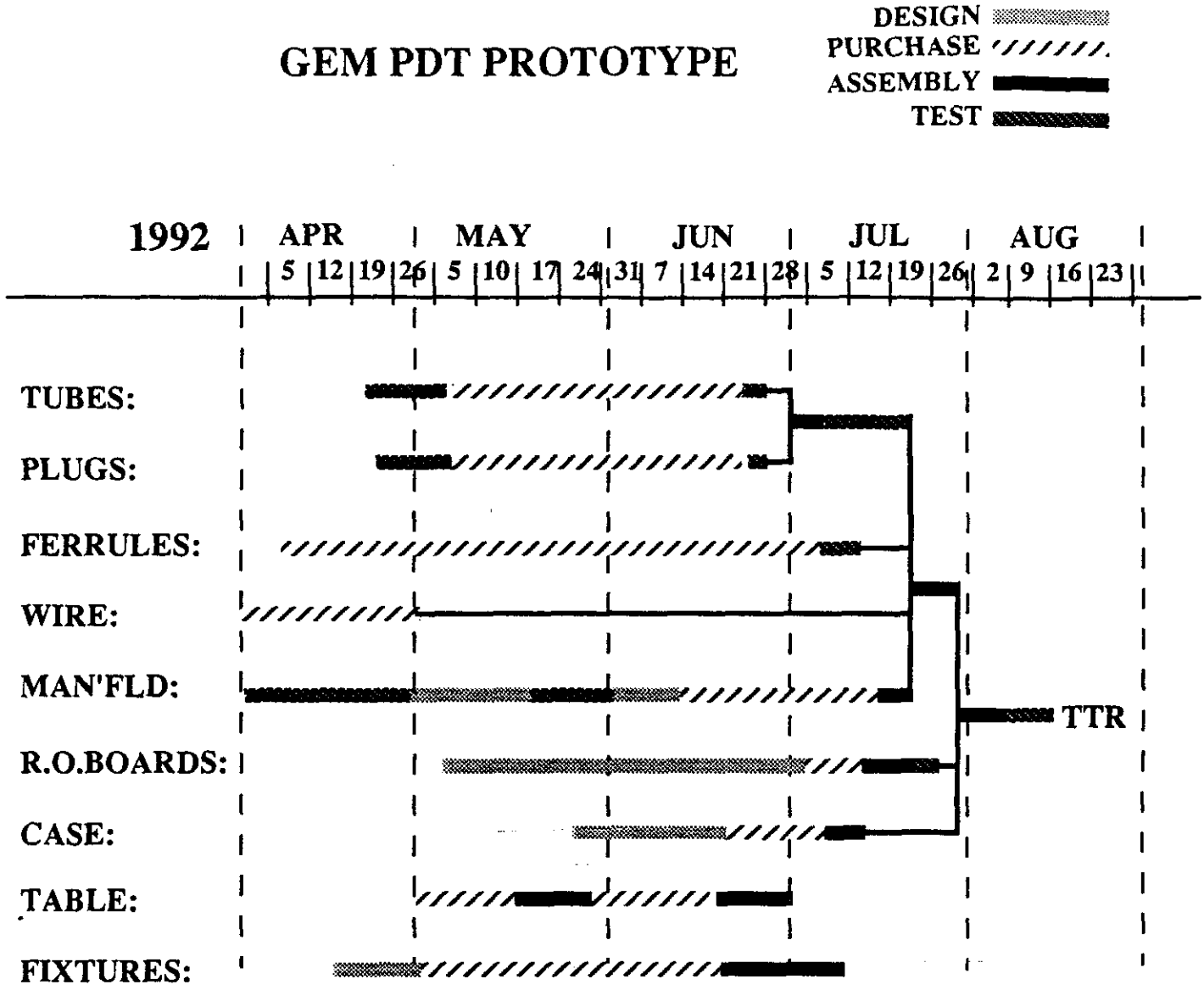
HEP01-022-281-D **R. Miller** **5-14-92**

PDT PROTOTYPE ASSEMBLY: 128 Tubes

Operation	Persons	Unit Time (hrs.)	Total Manhrs.	√
Inspect tubes	2	0.05	12.8	√
Cut tubes to length	2	0.05	25.6	√
Debur tubes	1	0.1	25.6	√
Clean tubes	2	0.05	12.8	√
Flair tube ends	1	0.1	25.6	√
Inspect plugs	1	0.05	12.8	√
Put O-rings onto plugs	1	0.05	12.8	√
Crimp plugs into tubes	2	0.1	51.2	
Pressure test tubes	1	0.1	12.8	
Inspect Manifold Plates	2	2	4	
Assemble Manifold Plates	2	5	20	
Setup Assembly Table	2	8	16	√
Assemble tubes into Manifold	2	0.1	25.6	
Bond tubes together	2	8	16	
Insert Wires into tubes	2	0.1	25.6	
Seal plug ends	1	0.05	6.4	
Install gas fittings	1	1	1	
Pressure test assembly	2	8	16	
HV test	2	0.05	12.8	
Test wire tension	2	0.1	25.6	
Assemble Case	2	10	20	
Install components on Boards	1	1	8	
Test Circuit Boards	1	0.5	4	
Assemble Power Buses	2	4	8	
Assemble R.O. Boards	1	1	4	
Assemble HV Boards	1	1	4	
Final testing	2	8	16	
Package for Shipping	2	8	16	
Total			441	
Fraction Completed	0.33			

R. J. MILLER 6/30/92

GEM PDT PROTOTYPE



Milestones:

Critical design complete: 28 Feb.

Critical P.O's complete: 15 Jun

Tube Assembly completed: 8 Jul.

Critical components in hand: 15 Jul.

Chamber Assembly completed: 7 Aug.

Chamber shipped to TTR: 14 Aug.

R. J. Miller
6-30-92

LSDT PROGRESS

Louis Osborne

GEM Note TN-92-122
June 29, 1992

NEUTRON SENSITIVITY OF LSDT CHAMBERS

(preliminary results)

A. Korytov, K. Linder, L. S. Osborne, F. E. Taylor

Massachusetts Institute of Technology

Laboratory of Nuclear Science

APPENDIX-NEUTRON BACKGROUND PROBLEMS

Given the neutron efficiency of our chamber and Laurie Waters' calculation of neutron fluxes then is the background rate disturbing?

Waters tells me by letter that the flux of neutrons after the calorimeter and 10 cm of borated polyethylene is 1.15×10^3 per cm^2 per second.

With our "efficiency" of 4×10^{-3} and typical single tube area of 2.5 cm x 1000 cm we get 11.5 kHz/wire. at the first layer.

Wire aging: Taking $\sim$ 50 picoCoulombs/pulse I get 5.75×10^{-3} Coul./cm of wire/year. It would take 174 years to get to the danger point, 1 Coul./cm. or 17.4 years at 10^{34} luminosity.

What is the chance rate to get a vector from 3 out of 4 layers firing within the drift time? I take the worst drift time , 0.5 μsec, i.e. using a CO_2 gas. I get 2.6 Hz. This does not make a level 1 trigger rate; one would require 2 such vectors in adjoining 4 layered chambers of a superlayer not to mention requiring near collinearity in the 3 superlayers.

CAVEATS:

1.) The neutron flux calculation includes only the neutrons exitting from the nearby parts of the calorimeter. Reflections of the higher fluxes at smaller angles back into the barrel region are not yet calculated- the magnet acting as a bottle.

2.) There will be capture gammas associated with the neutrons, also not calculated. However these should be of the same number as the neutrons.

3.) The total amount of B-poly moderator is not decided.

4.) Can one add Boron to the copper of the calorimeter. It makes a better compensated calorimeter and captures more neutrons, although the bad and more numerous neutrons are the "high" energy ones i.e. > 5 kev.

GEM Note TN-92-121
June 29, 1992

STUDIES OF CATHODE MATERIALS FOR THE LSDT

A. Korytov, K. Linder, E. Nehrlich,

L. S. Osborne, B. Rosenberg, D. Ross

Massachusetts Institute of Technology

Laboratory of Nuclear Science

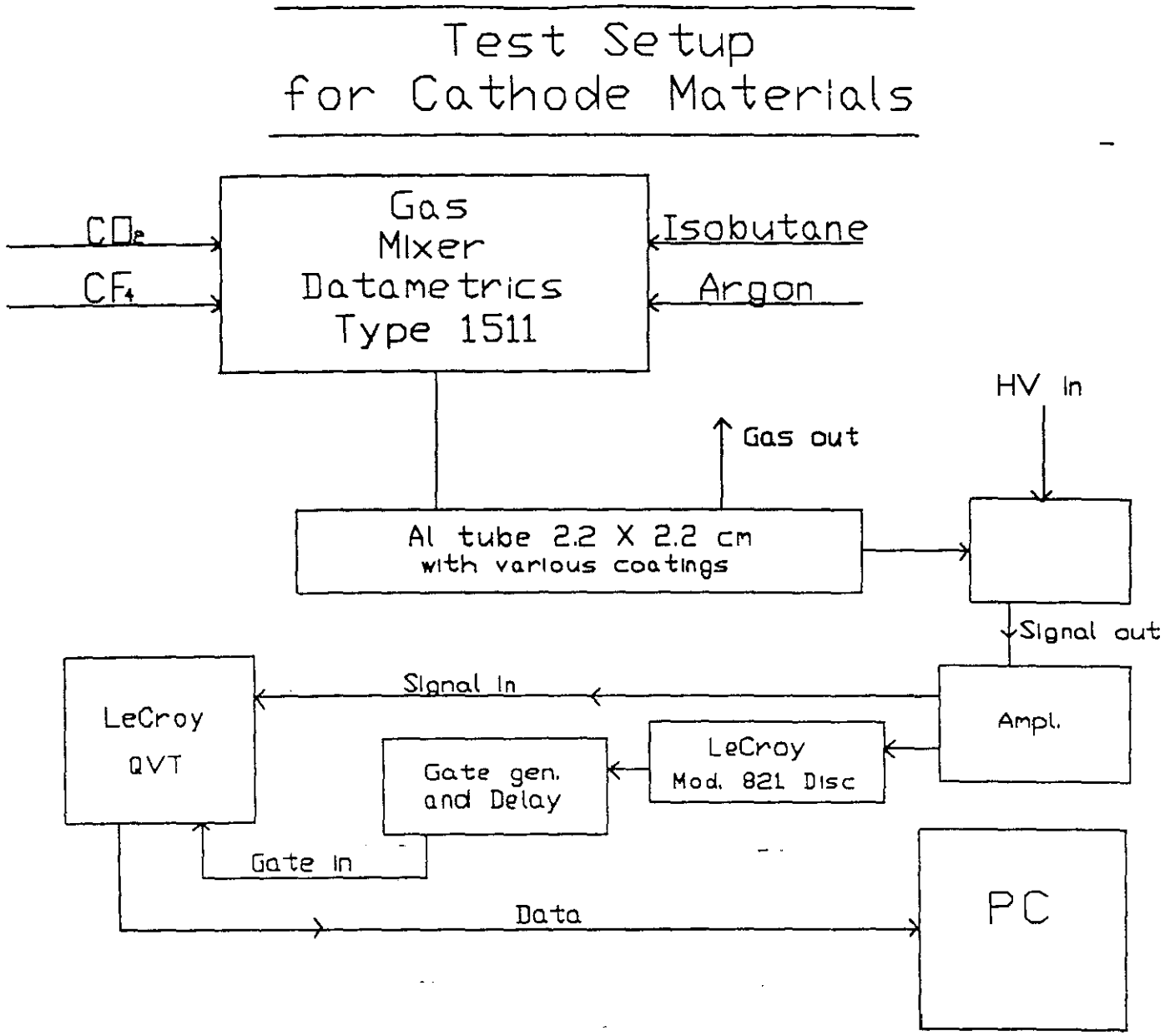


Fig. 1 A schematic representation of the experimental layout for the tests on various cathode materials

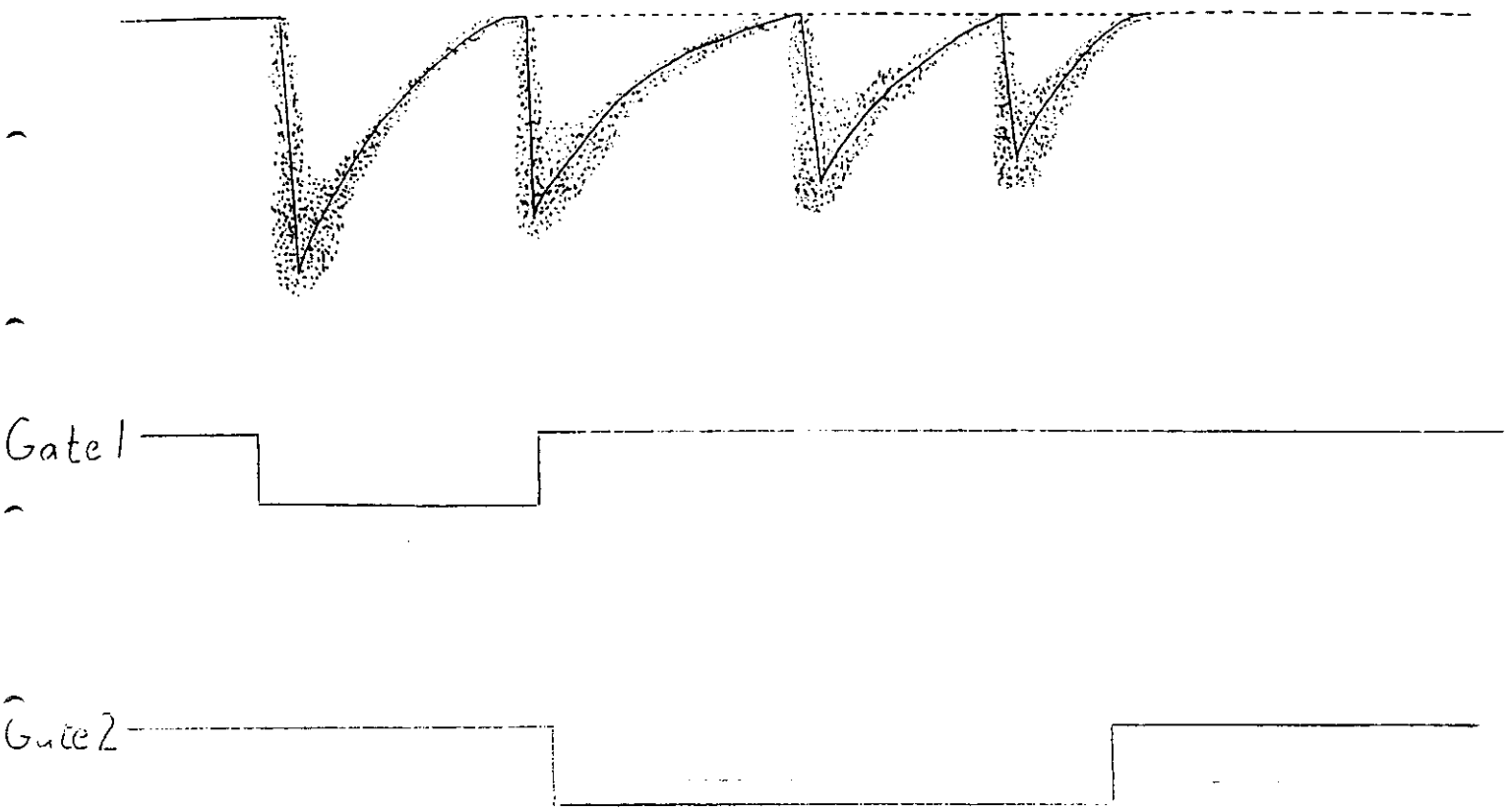
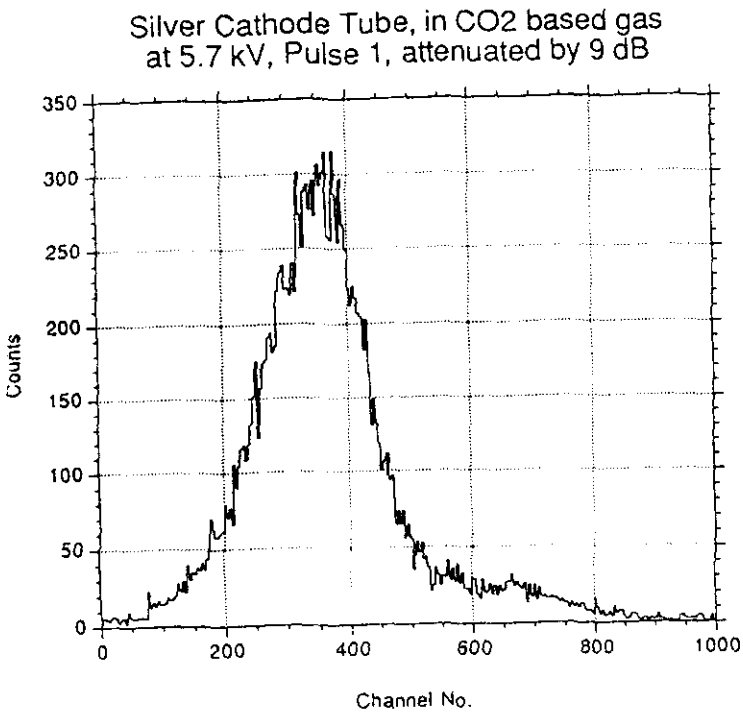


Fig. 2 Schematic of the timing gates for pulse height analysis of the first pulse (Gate 1) and secondaries (Gate 2).



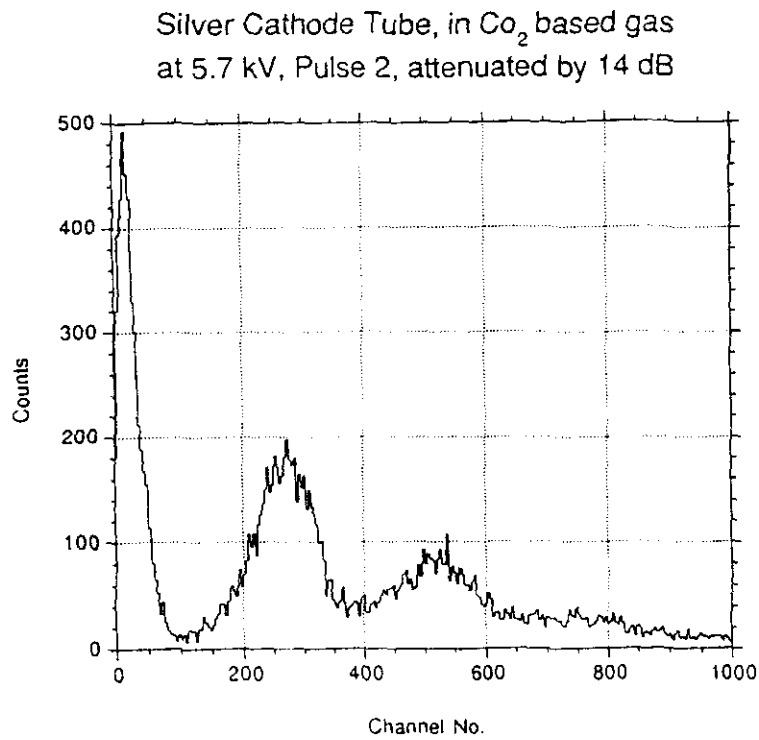
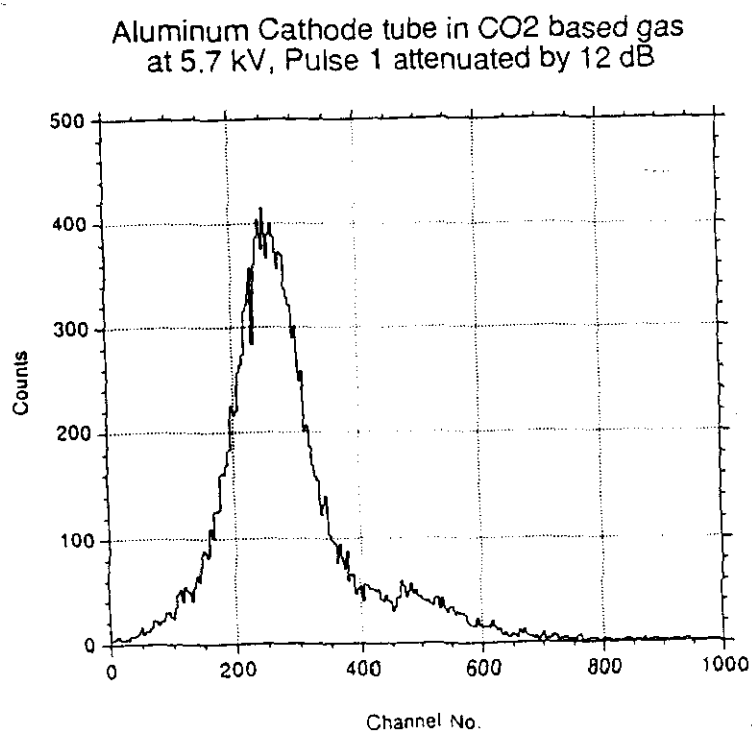
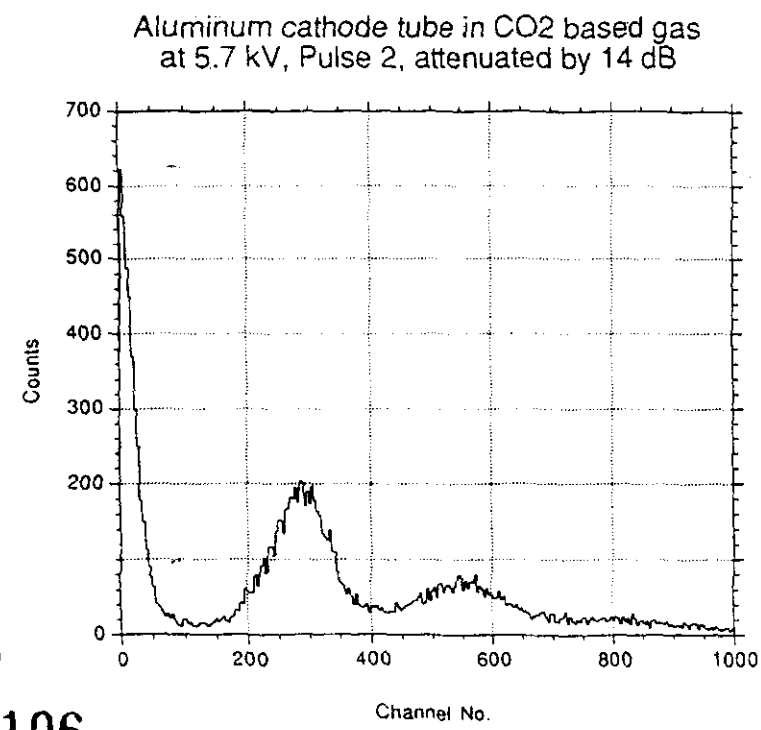
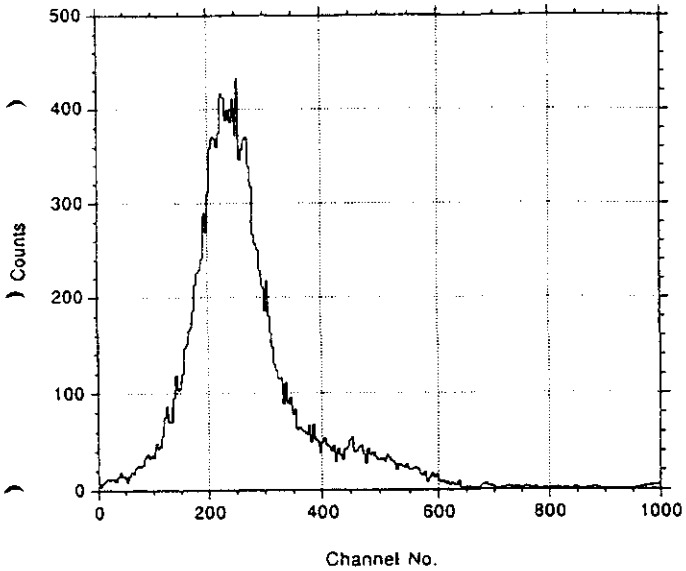


Fig. 3 Typical plots of pulse height (in charge) distribution for, a), first and, b), secondary pulse(s) for various cathode materials. The high voltage was always 5.7 kV; the gas was "CO_2".

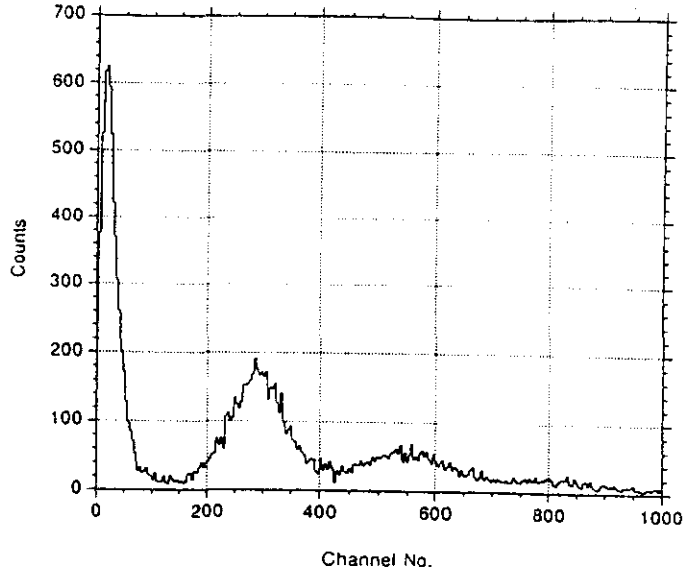




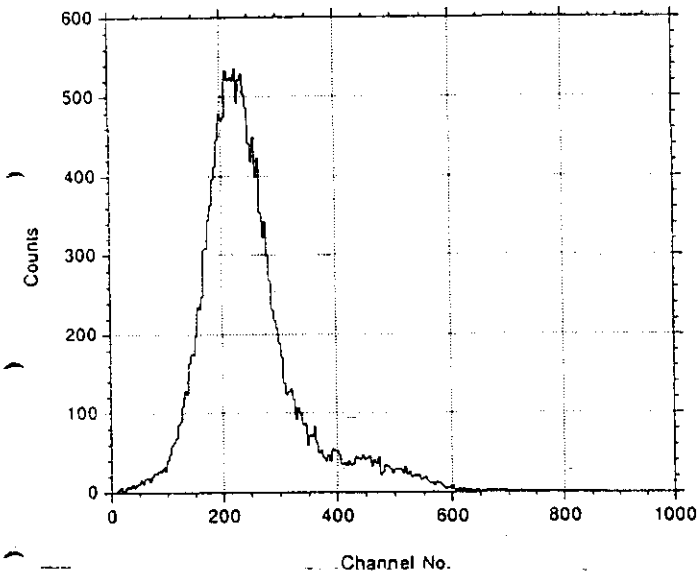
Nickel cathode tube, in CO_2 based gas
at 5.7 kV, Pulse 1, attenuated by 12 dB



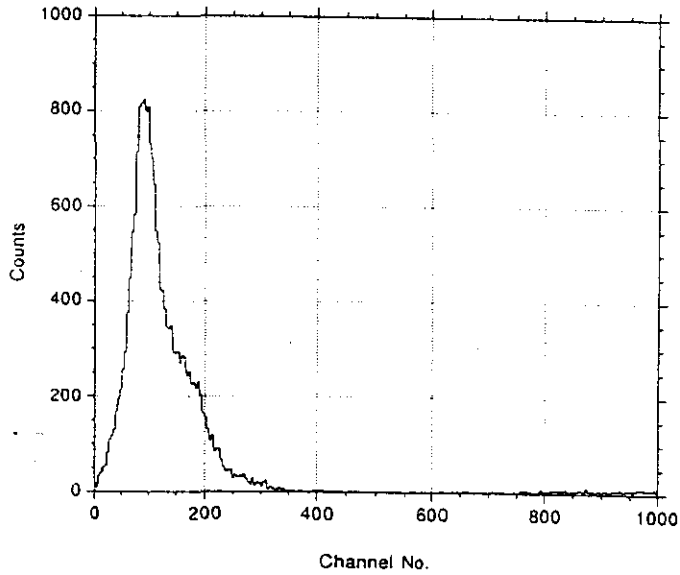
Nickel cathode tube, in CO_2 based gas
at 5.7 kV, Pulse 2, attenuated by 14 dB



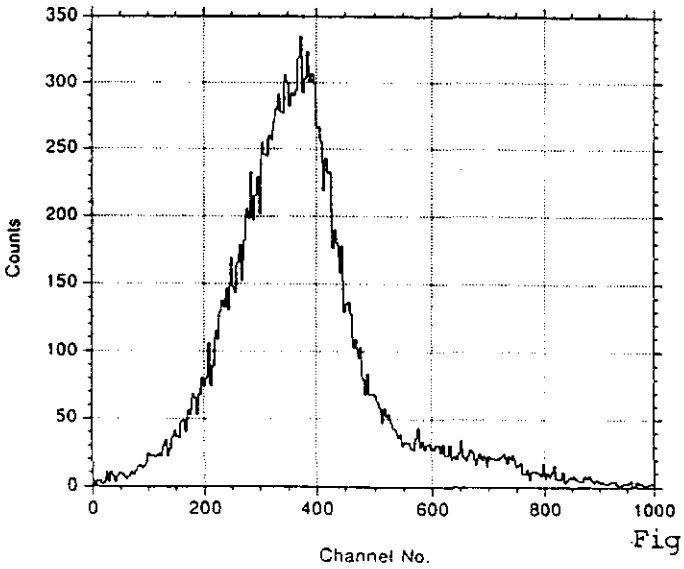
Carbon Coated Aluminum, in CO_2-based gas
at 5.7 kV, Pulse 1, attenuated by 12 dB



Carbon coated Aluminum, in CO_2-based gas
at 5.7 kV, Pulse 2, attenuated by 4 dB



Copper Cathode tube, in CO2 based gas
at 5.7 kV, Pulse 1, attenuated by 9 dB



Copper cathode tube, in CO_2 based gas
at 5.7 kV, Pulse 2, attenuated by 18 dB

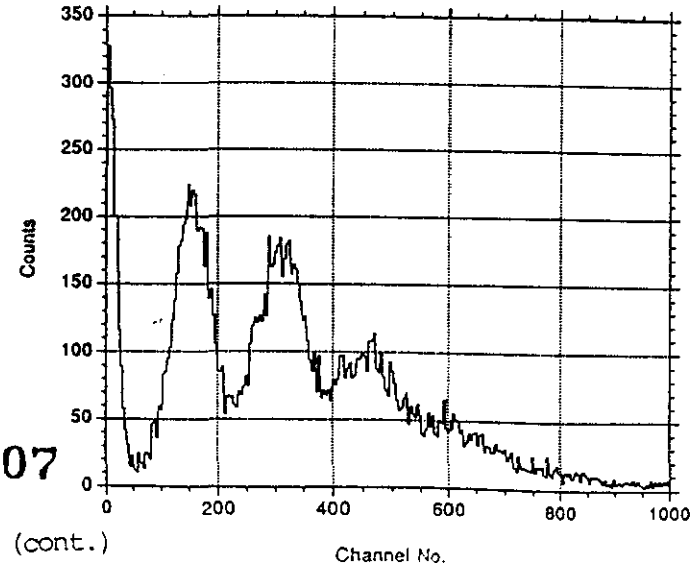
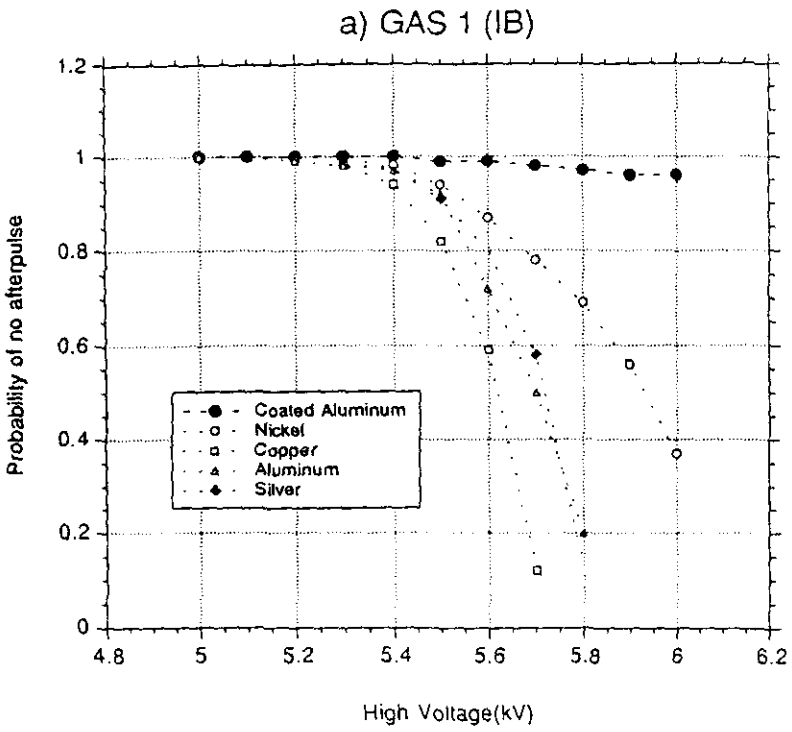


Fig. 3 (cont.)



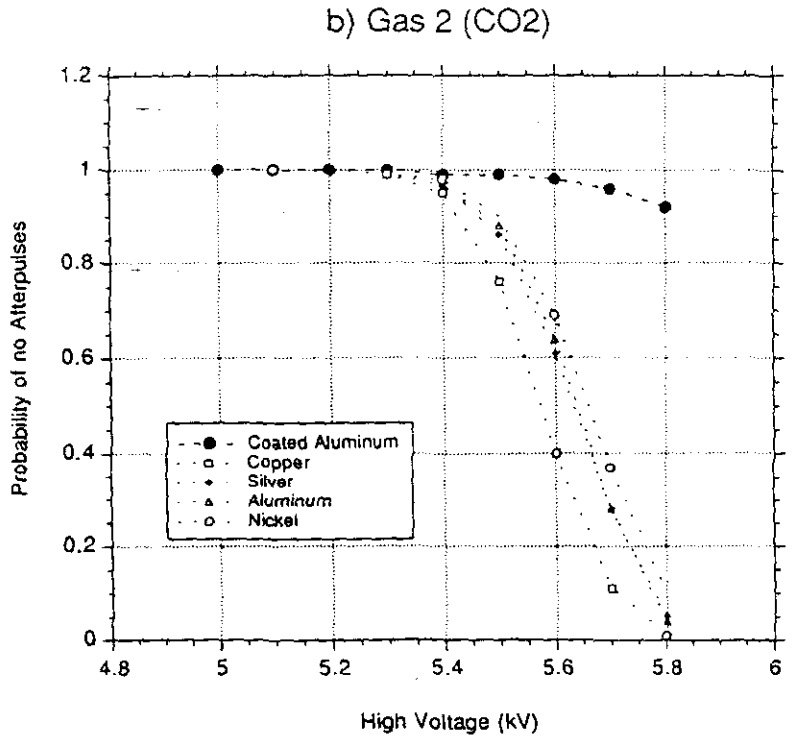


Fig. 4 Probability of after pulse(s) as a function of high voltage and for all cathode materials tested; a) CO_2 , b) IB. The plot for CF_4 is not shown; there was always an afterpulse.

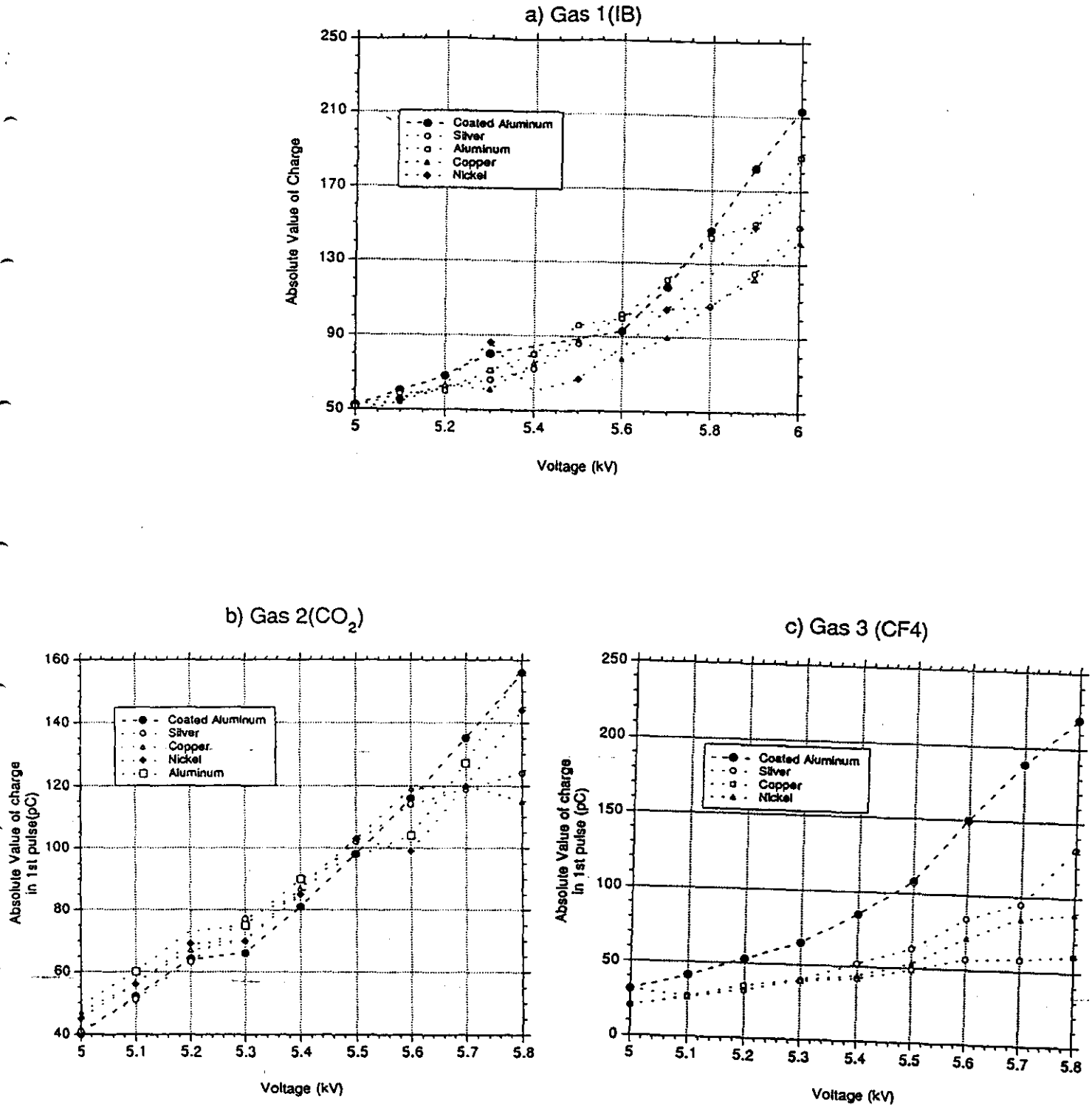


Fig. 5 Absolute value of the average charge in the first pulse vs. high voltage; a) IB, b) CO_2, c) CF_4. In principle the first pulse amplitude should be independent of the cathode material which does not appear to be the case for the CF_4 gas. We have no explanation for this.

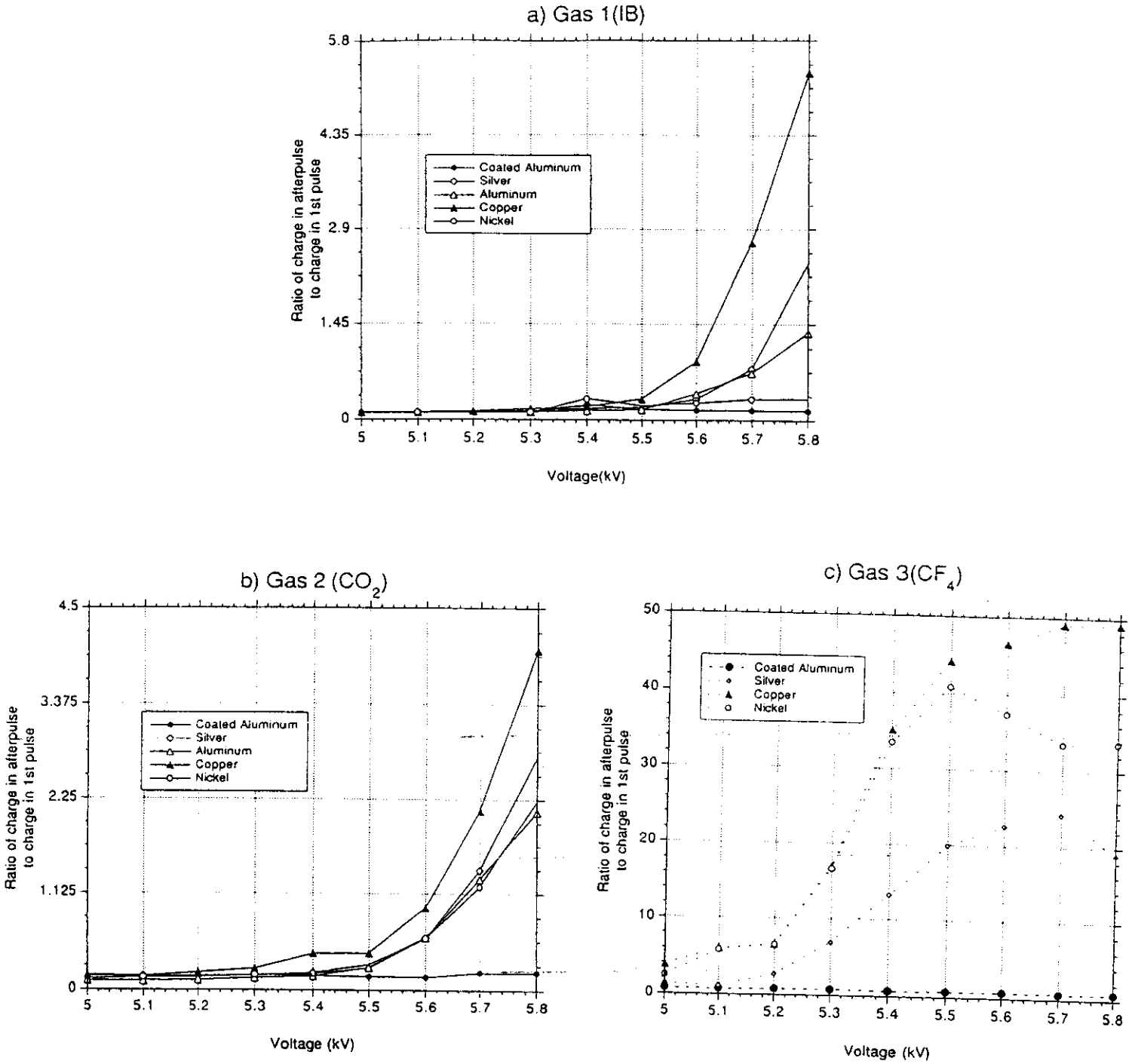


Fig. 6 Ratio of average charge in afterpulse(s) to average charge in first pulse as a function of high voltage. a) IB, b) CO_2, c) CF_4.

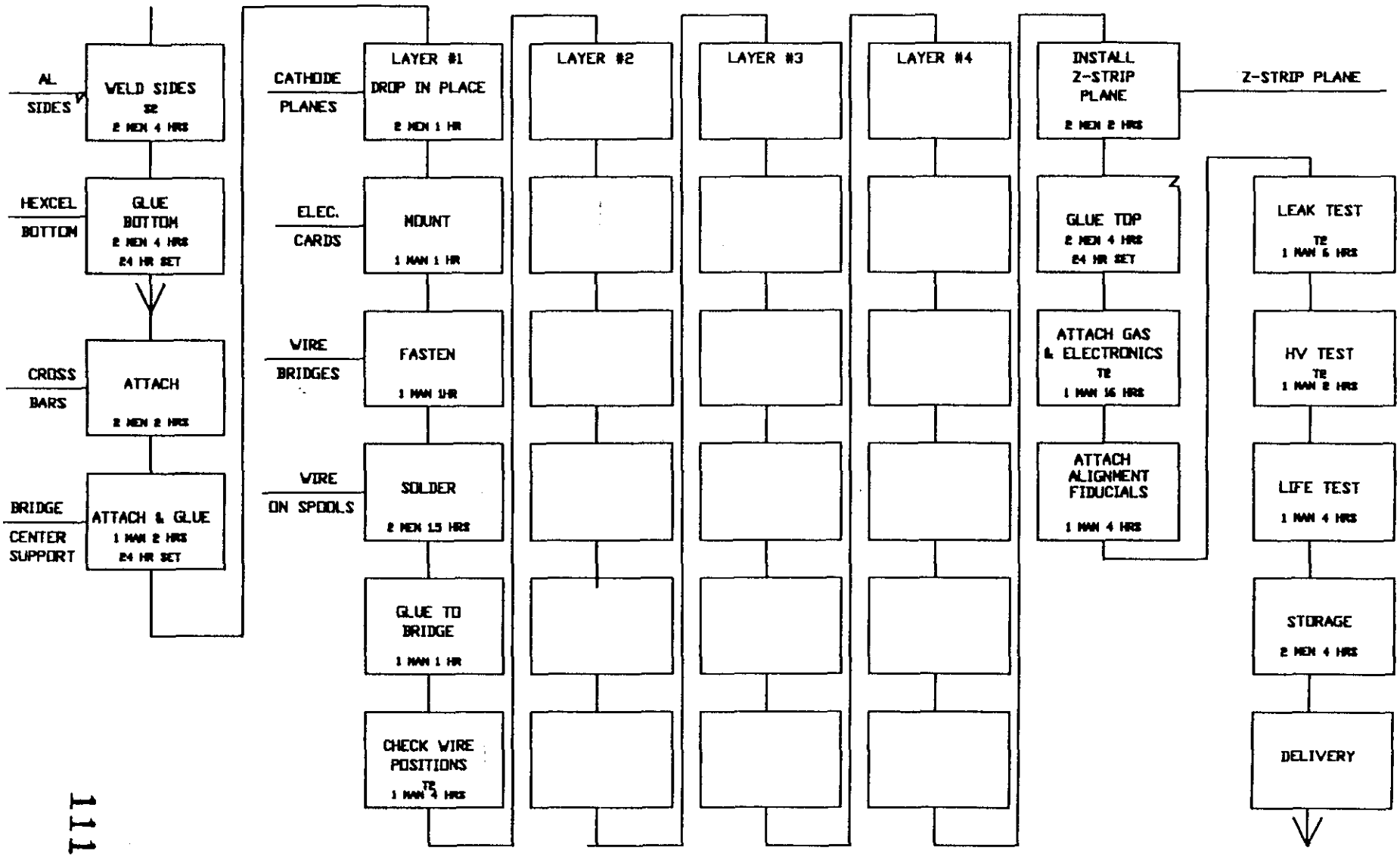


Fig. X.7 Block diagram of the assembly procedure in the chamber factory

LSDT Note
July 1, 1992

LSDT COST SUMMARY

WBS No.	Title	Cost in k$'s
03.2.1.2.3.1.1	Shipping and storage	217
03.2.1.2.3.1.2	Chamber testing	1054
03.2.1.2.3.1.3	Chamber assembly	3082
03.2.1.2.3.1.4	Factory preparation	839
03.2.1.2.3.1.5	Procurement and inspection	18802
03.2.1.2.3.1.6	Final design	525
03.2.1.2.3.1	Total	24519

Missing:

Electronics

Alignment costs

Gas system

Z pick up planes

LSDT Note
July 1, 1992

STATUS OF 1 METER X 4 METER CHAMBER

July 1 , 1992

	Part or Stage	Delivery Date (D=delivered)
Al boxes:machined and welded		7/15
Cathode planes (Lincoln Lab.)		7/15
Hexcel bottom and top		
	material	D
	preparation	7/20
Bridges		
	blanks	D
	machining	7/15
Posts		7/9
Wire(100 μm Au platted wire)		
	material	D
	soldering(courtesy of LLNL)	D
Electronics:		
	HV cards	7/20
	delay lines	7/20
	discriminator cards	7/31
Assembly:	Start	7/20
	Finish	7/31
Delivery to SSCLab		8/28

DRAPER ENGINEERING

H. Baker

MECHANICAL Eng.
update
@
DRAPER

3 July

H. BAKER

HOWARD BAKER
TEL# (617) 258-3411
FAX# (617) 258-1311
E-MAIL hbaker@draper.com

Muon Subsystem

Engineering status

Meeting

Date: 8 July

Day: WED

Time: 3PM to 5...6...?

Location: DRAPER

7/3/92

STATUS OF DRAPER ENG EFFORTS

- COST MATRIX (REV #11) UPDATED (6/23)
- ALIGNMENT DOC'S ISSUED
  - CONCEPTS
  - REQUIREMENTS
- INCLUDED IN PAC Q/A PACKAGE
- DESIGN TEAM BEEFED UP FOR PAC MTG
  - DRAWINGS
  - ANALYSIS

6/1/92 HWB
Rev 1

Preparation for July PAC Meeting

Gem Muon System Engineering/Draper Product

Details of Design

1. Muon system design
2. Muon System Alignment (Local)

1) Muon System Design (Nimblett)

a) Details (real drawings) of the support structure to include the following
   1) 3-dimensional drawings of modules with chambers, barrel region ass'y, end cap region ass'y
      (3 dimensional drawings will depend upon Draper personnel availability)
   2) Details of joints
      a) 3-D drawing of 1 joint *(same comment)*
   3) Details of structure attachment to magnet
   4) Details of interface hardware between chambers and support structure
      a) Chamber end with alignment hardware
      b) Chambers in structure
      c) Coverage in θ and ϕ for PDTs and LSDTs
      d) Module installation process (Barrel and Endcap)

b) Discussion of structural and thermal analysis for both regions

c) Individual module concept for barrel region

2) Muon System Alignment/Local (Paradiso)

a) Proposed local alignment scheme and analysis of performance
   1) Baseline alignment system will be composed of 3-point optical straightness monitors and stretched wire devices (SWAT's)
   2) Identify spacers for monitoring chamber spacing
   3) Define alignment lines-of sight, needed clearances, fixture locations, and spacers to the drawings of the muon system

FRANK NIMBLETT
8 JUNE 1992

(DRAFT)

Please review and make comment !!

GEM Muon Effort For June
(Preparation for July PAC Meeting)

GENERAL BACKGROUND INFORMATION:

- MUON SYSTEM DESIGN WILL BE BASED ON THE CONCEPT OF BARREL REGION MODULES INDEPENDENTLY MOUNTED TO THE MAGNET ENDPLATES (16 MODULES PER END)
- BOTH BARREL REGION DRIFT CHAMBER OPTIONS (PDTS AND LSDTS) MUST BE REPRESENTED!
- BARREL REGION Z-MEASUREMENT & TRIGGER CHAMBERS (RPCS) MUST ALSO BE REPRESENTED FOR BOTH DRIFT CHAMBER OPTIONS.
- ENDCAP CAP MUON SYSTEM WILL BE CATHODE STRIP CHAMBERS (CSCS), WITH OVERLAP BETWEEN MODULES IN PHI (ANGLE ABOUT THE BEAMLINE) AND THETA (ANGLE FROM THE BEAMLINE).
- ENDCAP MUON SYSTEM SUPPORT WILL BE INDEPENDENT OF BARREL REGION MUON SYSTEM AND PREFERABLY A 3 POINT MOUNT FOR VERTICAL LOADS; AXIAL RESTRAINT MUST ALSO BE INCLUDED FOR STABILITY
- GEM BASELINE SPECIFICATION IS THE SOURCE OF INTERFACE INFORMATION!!
- ALL OUTPUT TO BE ILLUSTRATED IN METRIC SYSTEM!!
- ALL FIGURES TO BE PLANNED FOR 8.5 x 11 FORMAT
- ALL FIGURES, GRAPHS, TABLES WHICH ARE PRODUCED SHOULD BE FULLY LABELED AND DATED AND PRODUCED IN BOTH PAPER HARDCOPY AND TRANSPARENCY FORMAT (2 COPIES OF EACH PREFERABLE)
- ALL STRUCTURAL ANALYSIS OUTPUT SHOULD INCLUDE A BRIEF STATEMENT OF THE PROBLEM WITH BOUNDARY CONDITIONS PLUS A SUMMARY SHEET OF PERTINENT DEFLECTIONS AND OR STRESSES WHICH CAN BE RELATED TO AN UNDERSTANDABLE WELL LABELED FIGURE OR FIGURES.

DETAIL INFORMATION: (OUTPUT EXPECTED FOR JULY PAC MEETING, DUE BY JUNE 30) ----------(RESPONSIBLE PERSON)

- BARREL REGION AND ENDCAP REGION MUON SUPPORT STRUCTURES

  - CHAMBER LAYOUTS FOR BOTH DRIFT CHAMBER TYPES AS WELL AS THE RPC POSITIONS FOR EACH DRIFT CHAMBER TECHNOLOGY---- ----------F. NIMBLETT

  - CHAMBER COVERAGE FOR THE DETECTOR ----------F. NIMBLETT

  - ELEVATION AND ENDVIEWS OF EACH CHAMBER OPTION INCLUDING THE RPCS WITH APPROPRIATE STRUCTURE (PLATE IN MIDDLE CHAMBER AREA TO BE INCLUDED!!).---------- ----------M. DEPIERO/B. BIGGIO

  - 3D PICTURES OF CHAMBERS AND MODULES (IDEAS / PATRAN) FOR BOTH REGIONS (ALTERNATIVE OPTION IS TO PROVIDE 3 VIEWS)------- -----M.FUREY / T. HINES (3D)------OR M. DEPIERO/B. BIGGIO (3 VIEWS)

  - DETAILS OF SUPPORT STRUCTURE DESIGN ----------(MIKE DEPIERO & BETTY BIGGIO)
    - OVERALL STRUCTURE (DETAILS OF TRUSS ELEMENTS (2))
    - JOINT DETAILS (AT LEAST TWO, INCLUDING PLATE JOINTS)
    - DETAILS OF INTERFACE WITH MAGNET ATTACHMENT PLATE
    - DETAIL OF STRUCTURE / CHAMBER END / ALIGNMENT LINES OF SIGHT (CONCEPTUAL BUT TIED TO ACTUAL DRAWINGS) ---------- ----------(T. KONDOLEON/DRAFTING)

  - ANALYSIS OF STRUCTURE FOR BOTH REGIONS:----------M. FUREY
    - BARREL REGION ANALYSIS (INDEPENDENT MODULES WITH PLATE STRUCTURE) (DEFORMATION AND STRESS)
    - MAGNET ATTACHMENT PLATE
    - BARREL REGION INSTALLATION CALUCULATIONS FOR MODULE, INTERFACE PLATE AND CRYOSTAT (DEFORMATION AND STRESS)
    - ENDCAP REGION INSTALLATION (DEFORMATION AND STRESS).
    - ENDCAP REGION (ASSEMBLY OF 16 MODULES WITH 3-POINT VERTICAL MOUNT AND EXTRA TRIANGULAR TRUSS) (DEFORMATION AND STRESS).
    - THERMAL ANALYSIS ONLY IF EVERYTHING ELSE COVERED!

  - ANGULAR PHI COVERAGE DWGS. (PDT AND LSDT)----B. BIGGIO

- DETAILS OF CHAMBER / STRUCTURE INTERFACE / WITH ALIGNMENT
  ----------(TONY KONDOLEON / DRAFTING)

  - INNER AND OUTER CHAMBER LAYER REQUIREMENTS: (FLEXURAL FEET WITH ADJUSTMENT CAPABILITY FOR LEVELING OF CHAMBERS , MANUAL LATERAL ADJUSTMENTS, LOCKS, AXIAL ADJUST / RESTRAINT ALONG WITH SOME INDICATION OF CHAMBER END CONSTRUCTION)(ALL CHAMBERS OPTIONS SHOULD BE INDICATED IN SOME SIMPLE FORM TO POINT OUT THE DIFFERENCES BETWEEN THE TECHNOLOGIES)

  - MIDDLE CHAMBER LAYER REQUIREMENTS: (FLEXURAL FEET WITH ADJUSTMENT CAPABILITY FOR LEVELING OF CHAMBERS , MANUAL LATERAL ADJUSTMENTS, NO LOCKS, AXIAL ADJUST / RESTRAINT ALONG WITH SOME INDICATION OF CHAMBER END CONSTRUCTION, LATERAL SERVO SYSTEM TO POSITION MIDDLE CHAMBER, CHAMBER WEIGHT UNLOADING SYSTEM 1) (PNEUMATIC) TO UNLOAD SERVO SYSTEM DURING ADJUSTMENT OPERATION) 2) (LONG THROW SPRING SYSTEM SO THAT THE SERVO WORKS AGAINST A SOFT SPRING)

- BARREL REGION AND <u>ENDCAP REGION</u> MUON INSTALLATION
  ----------M. DEPIERO

  - INSTALLATION SEQUENCE WITH SEVERAL <u>SIMPLE</u> VIEWS ILLUSTRATING <u>PERTINENT FIXTURING</u> FOR <u>BOTH REGIONS.</u>

  - DETAIL ONLY CRITICAL FEATURES AND EVEN THEN KEEP IT SIMPLE!!

  - INDICATE HOW TRANSITION IS MADE BETWEEN INSTALLATION HARDWARE AND THE FINAL MOUNTING HARDWARE TO THE MAGNET!!

  - INDICATE ADJUSTMENT CONSIDERATIONS TO PROPERLY POSITION A BARREL MODULE IN ITS DESIRED ORIENTATION.

  - INDICATE MEANS OF TRANSFERRING LOAD FROM FFS TO MAGNET FOR THE "THREE-POINT MOUNT WITH AXIAL RESTRAINT" FOR THE ENDCAP STRUCTURE.

6/17/92
HWB

OVERVIEW

NEAR TERM TASKS

I. COST REVIEW UPDATES
- 1) PRESENTATION STATUS FOR 6/23-24 COST MEETING
- 2) NEW INFO FROM WUEST ON RPCs/BROMBERG ON PDTs

II. BASELINE II & PAC
- 1) NEW TEXT FOR MAJOR SECTIONS
- 2) UPDATED MILESSTONES
- 3) FLUX CONCENTRATOR AT 9.4 DEG & NONPROJECTIVE
  - -NEW B-FIELD CALCULATIONS
  - -NEW RESOLUTIONS SIMS
- 4) BARREL-KEEP 8-8-4 CONFIG
- 5) ENDCAPS-COST AND 8-8-4 CSC CONFIG
- 6) UPDATE DRAWINGS OF CHAMBER CONSTRUCTION
  - -REQUEST HAS BEEN MADE OF THE TECH-PROPONENTS
- 7) SUPPORT STRUCTURE
  - -DETAILS OF TRUSS WORK/BARRELS&END-CAPS
- 8) DEPLOYMENT OF CHAMBERS IN SUPPORT STRUCTURE
  - -OVERLAP/NON-OVERLAP
  - -COVERAGE
  - - LEVER ARM
  - - MATERIAL DISTRIBUTION
- 9) UPDATED TABLES
  - - CHAMBER WEIGHTS
  - - CHANNEL COUT
  - - GAS VOLUMES
- 10) ALIGNMENT SYSTEM
  - - TABLE OF REQ (TOLERANCE FOR ALL DIMENTIONS
  - - COMPARISON OF ALIGNMENT TECHS
  - - ALIGNMENT PATHS DELINEATED ON SUPPORT STRUCTURE
  - - MATRIX OF TRANSFERS
- 11) UPDATED SIMULATION
  - - BACKGROUNDS (WITH NEW CALORIMETER
  - - TRIGGER
  - - RESOLUTIONS (8-8-4 IN ENDCAPS, NEW FC)

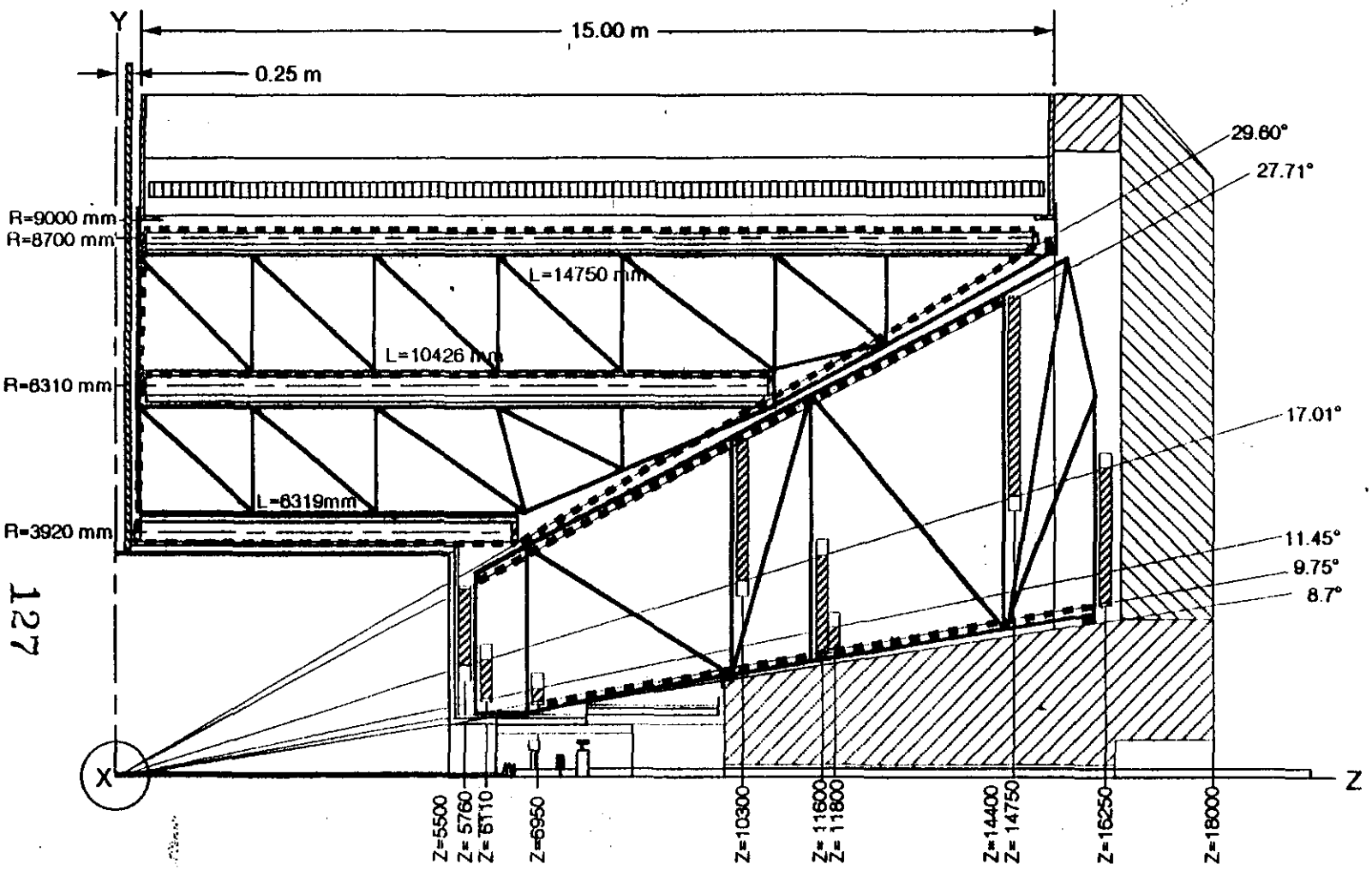
Sample

of

DRAWINGS

Available FOR

PAC PRESENTATION

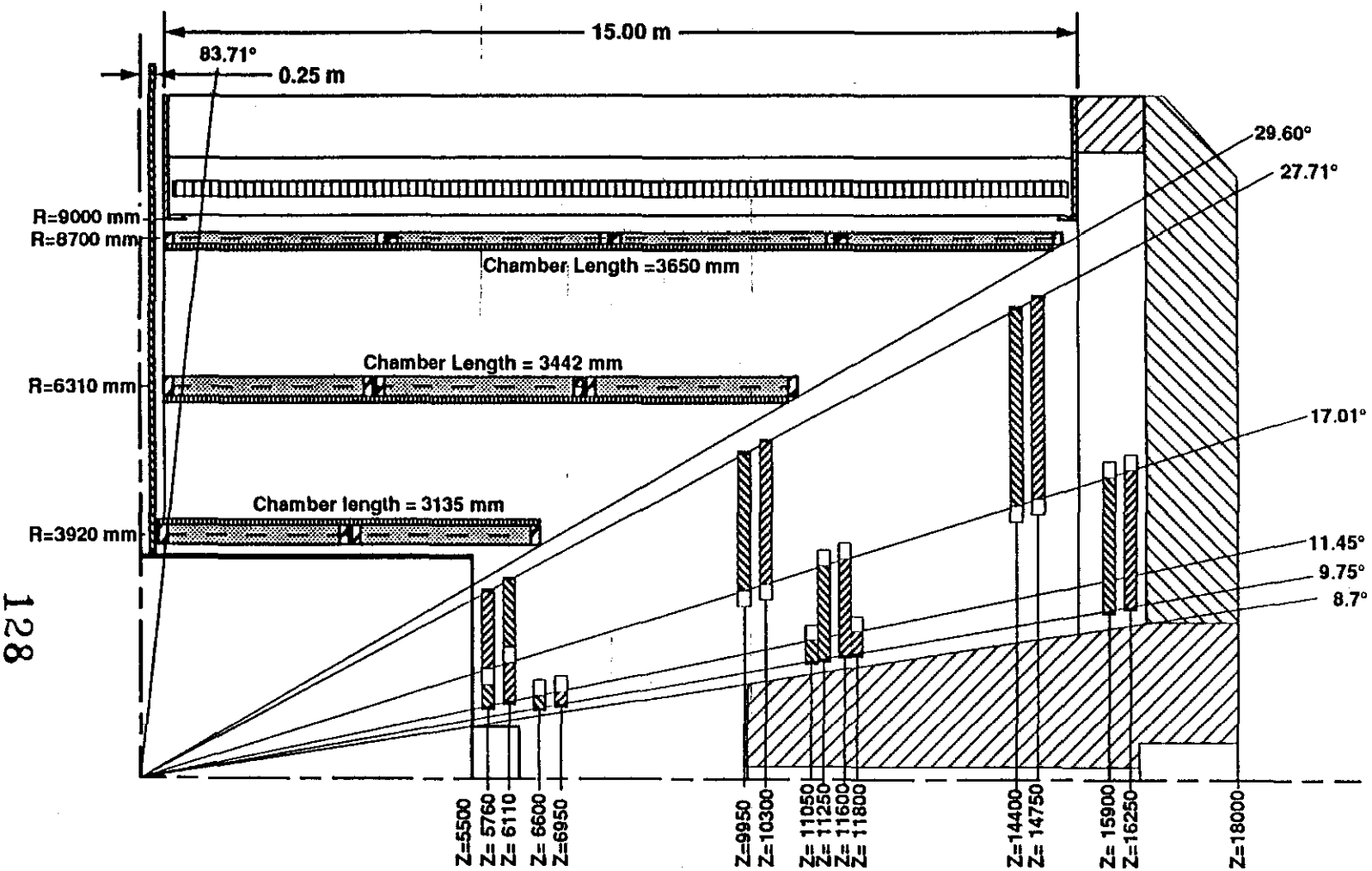


GEM MUON SYSTEM (BASELINE I)
(Alignment Line Layout)

Projective Lines - - - - -

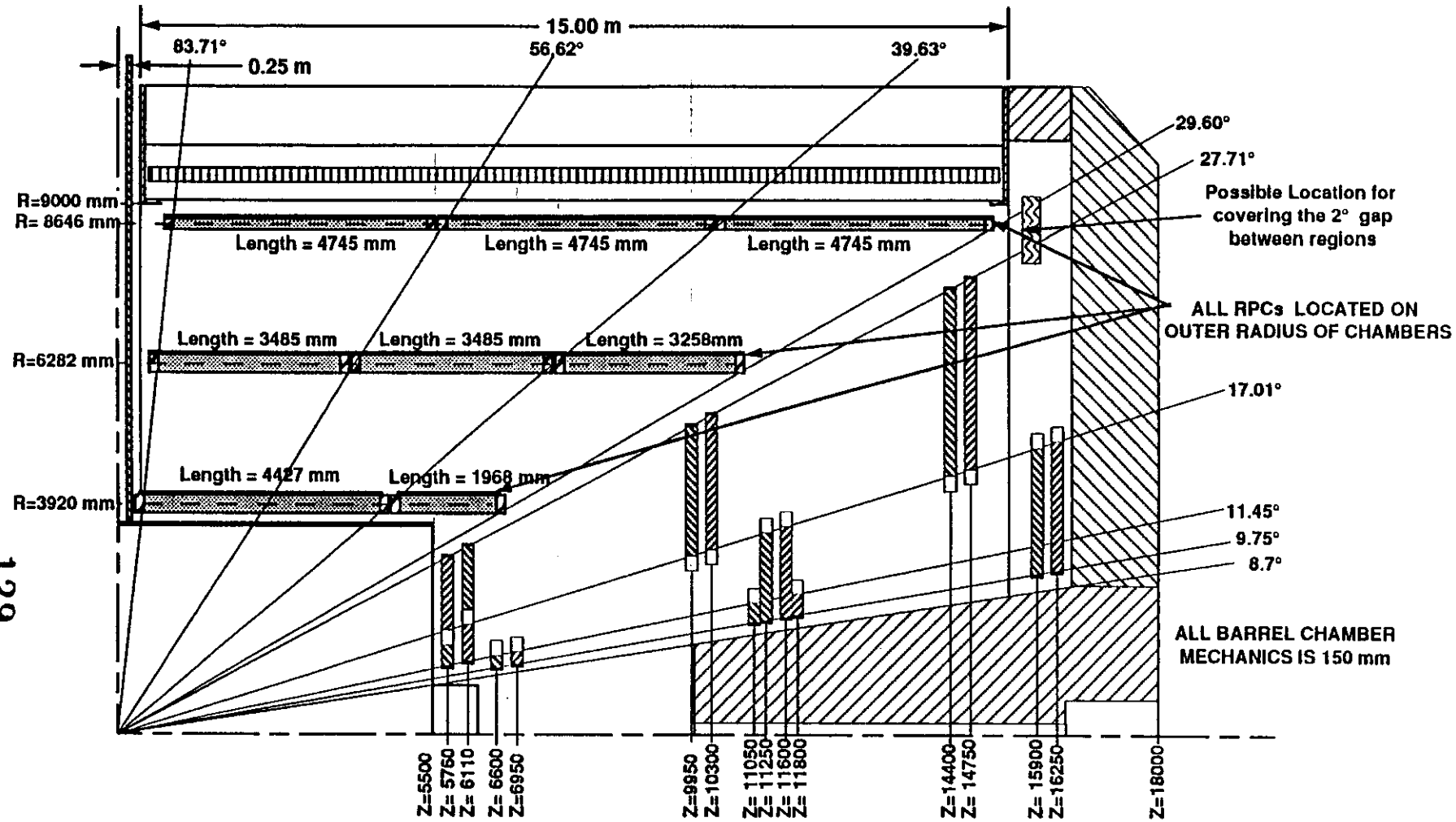
Barrel Parallel to Beam Line - - - - -

Draper Laboratory	
GEM Muon System (BASELINE) (Alignment Line Layout)	
Drawn By: F. Nimblett	Rev (-)
Dwg. No: GMU0013	6/30/92
Approved by:	



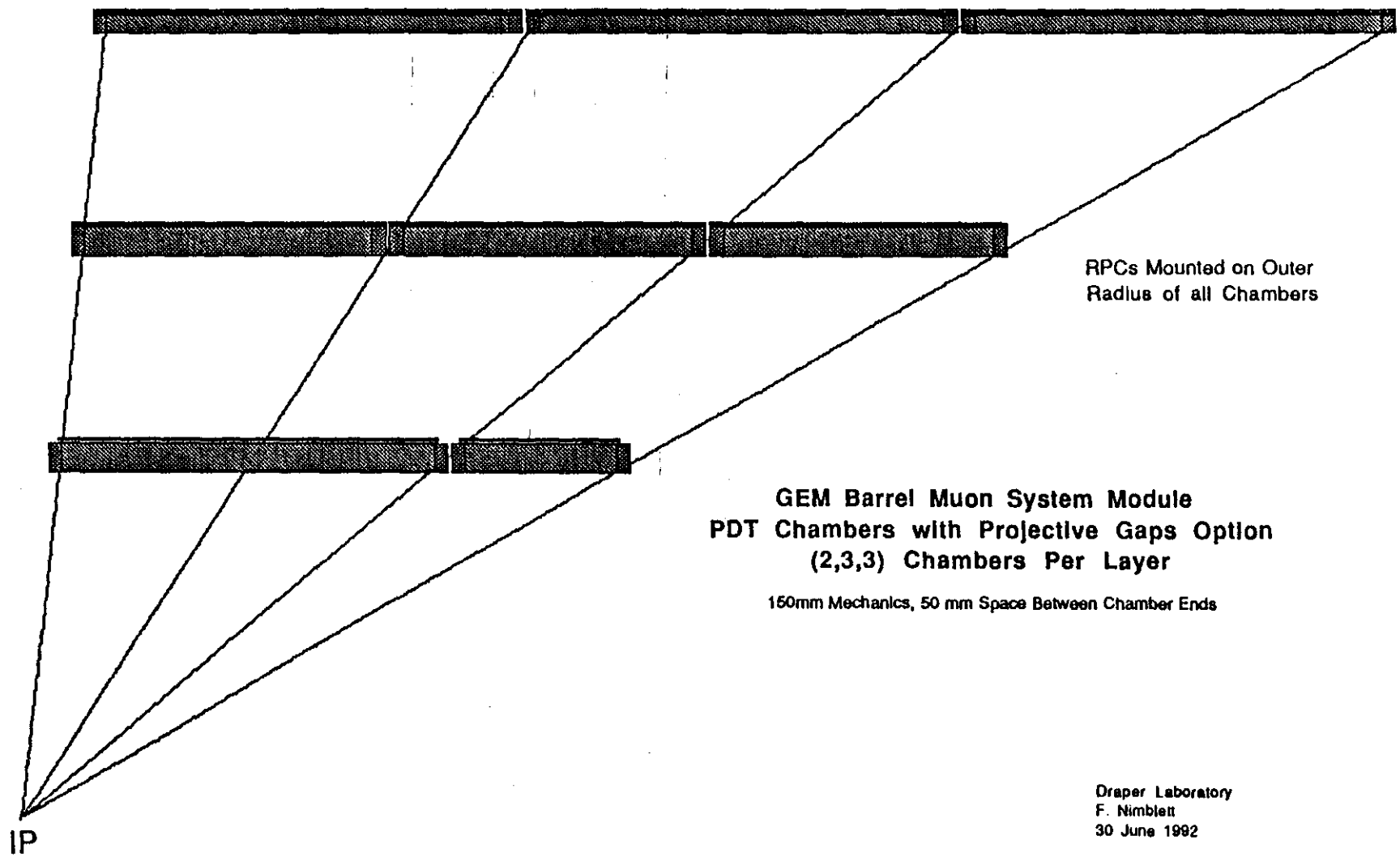
GEM MUON SYSTEM CHAMBER LAYOUT
BASELINE I
(2,3,4 PDT Chambers per Layer)

Draper Laboratory	
GEM Muon System PDT Baseline Chamber Layout	
Drawn By: F. Nimblett	Rev (-)
Dwg. No: GMU0014	6/30/92
Approved by:	



GEM MUON SYSTEM CHAMBER LAYOUT
BASELINE II
(2,3,3 Chambers per Layer-PROJECTIVE GAPS)

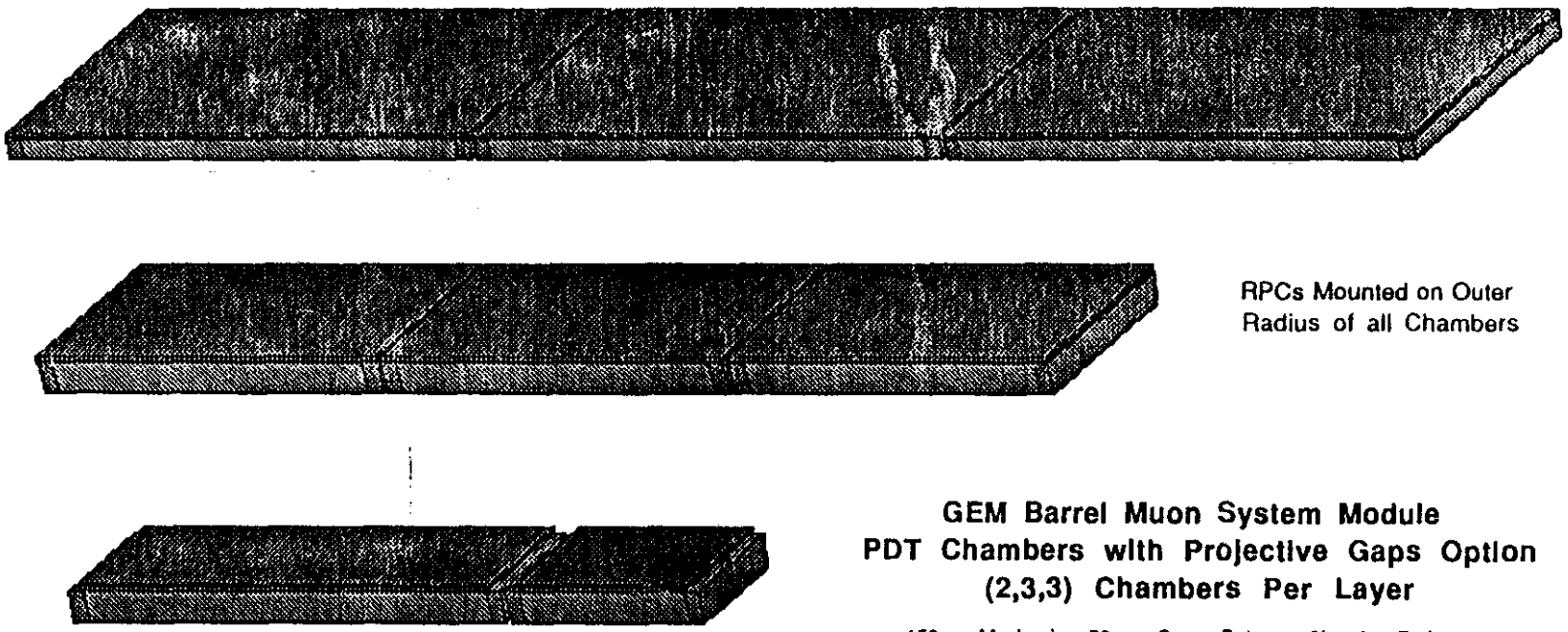
Draper Laboratory	
GEM Muon System Chamber Layout	
Drawn By: F. Nimblett	Rev (-)
Dwg. No: GMU0015	6/30/92
Approved by:	



GEM Barrel Muon System Module
PDT Chambers with Projective Gaps Option
(2,3,3) Chambers Per Layer

150mm Mechanics, 50 mm Space Between Chamber Ends

Draper Laboratory
F. Nimblett
30 June 1992



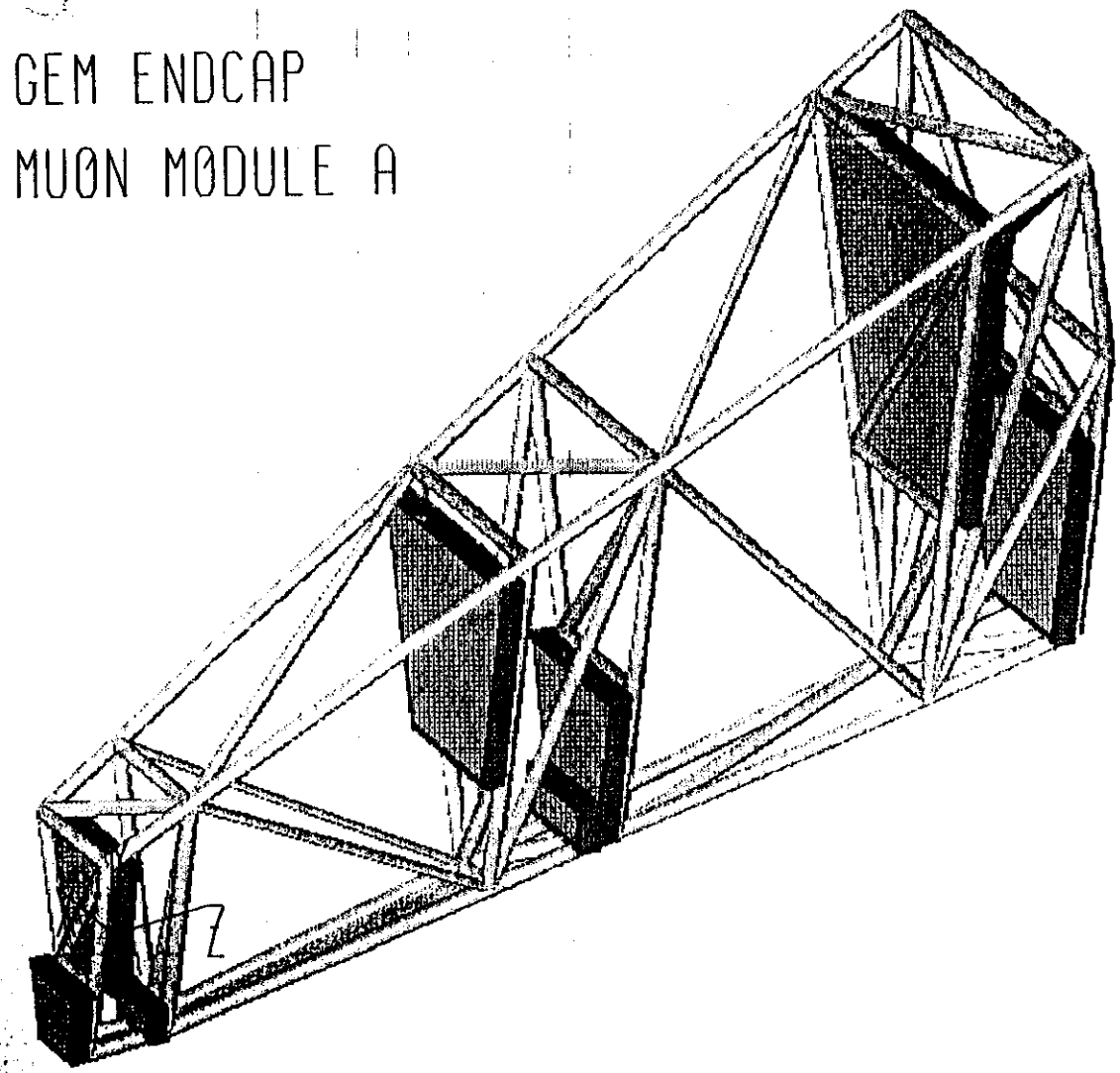
RPCs Mounted on Outer
Radius of all Chambers

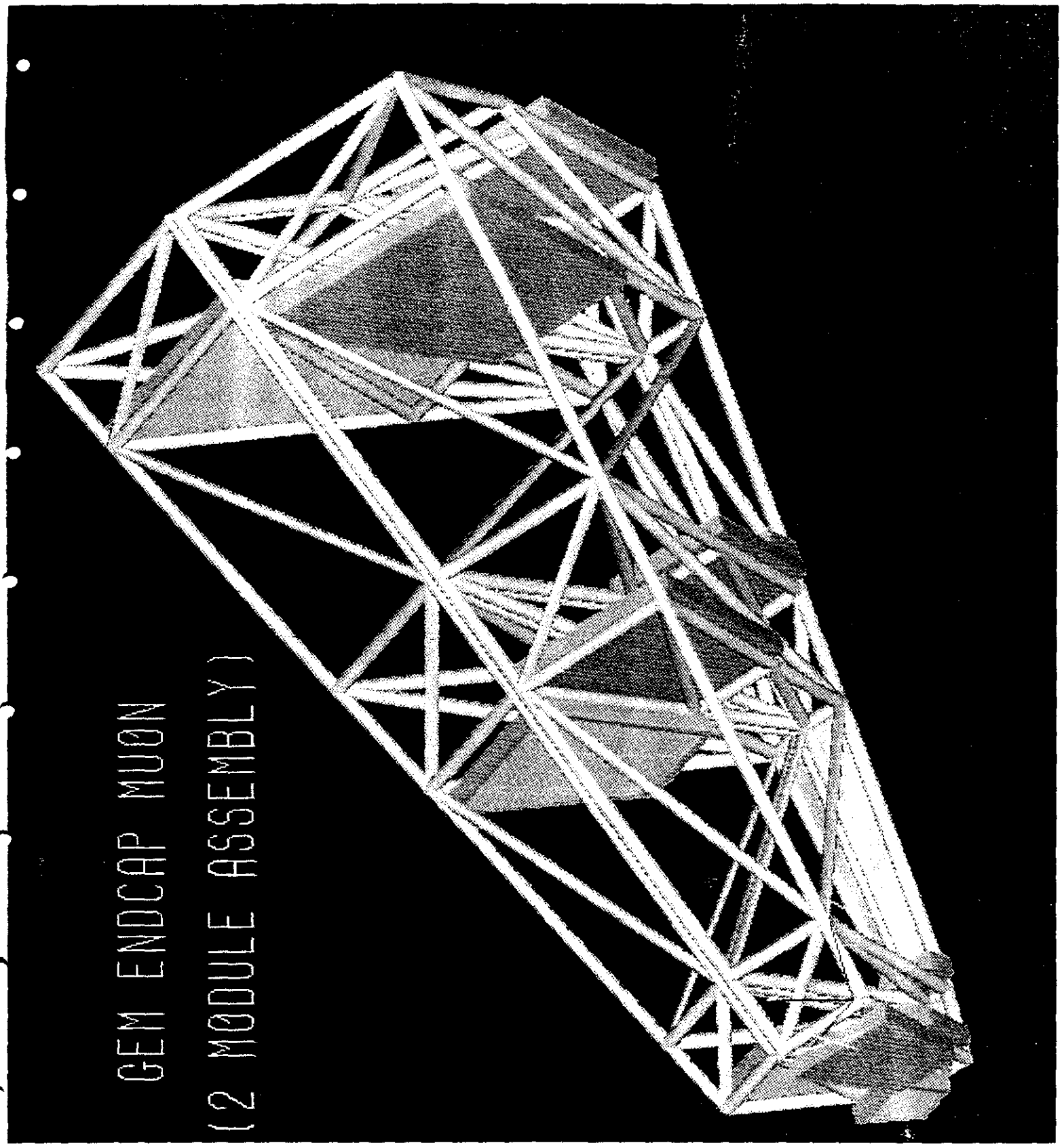
GEM Barrel Muon System Module
PDT Chambers with Projective Gaps Option
(2,3,3) Chambers Per Layer

150mm Mechanics, 50 mm Space Between Chamber Ends

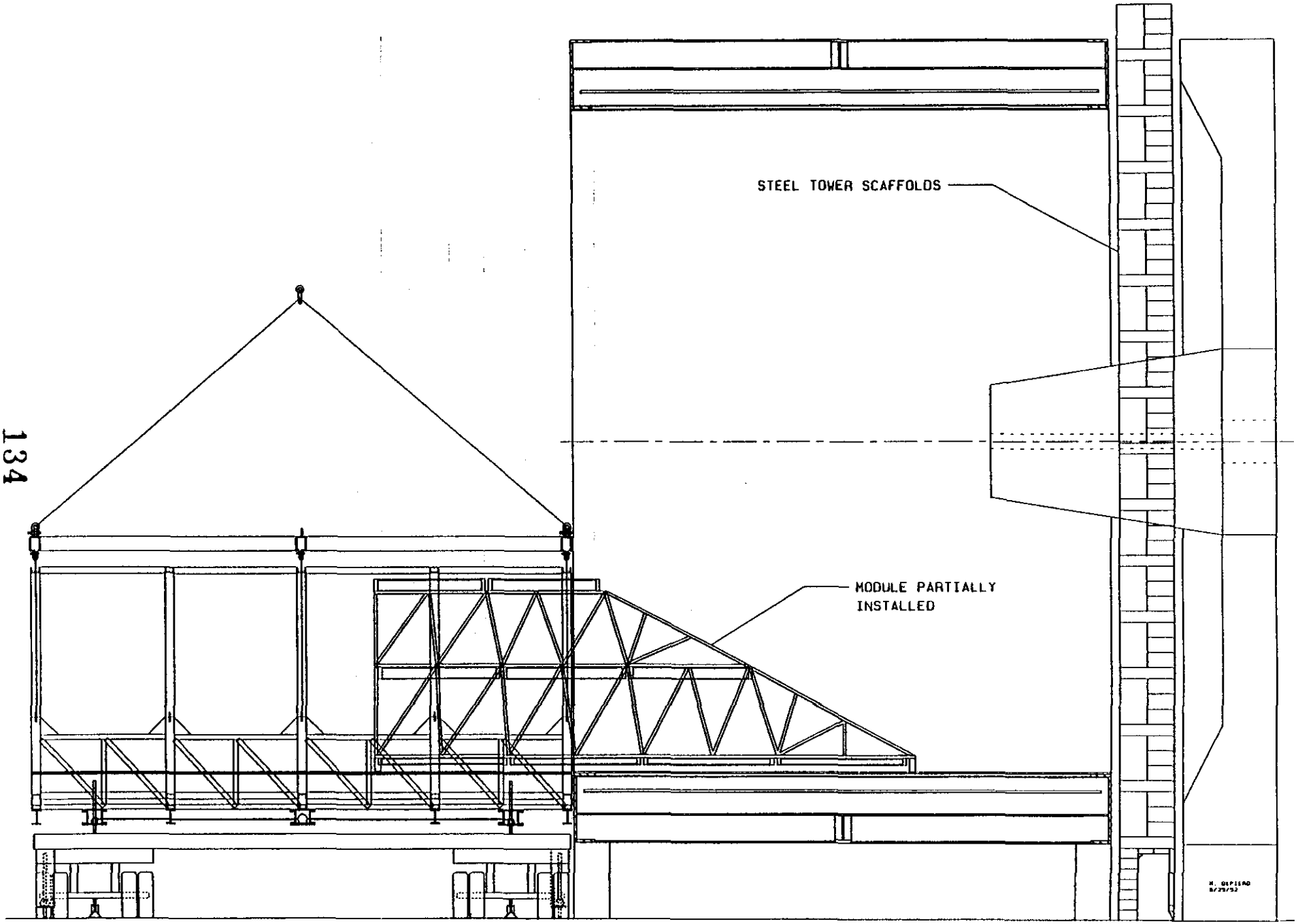
Draper Laboratory
F. Nimblett
30 June 1992

GEM ENDCAP
MUON MODULE A

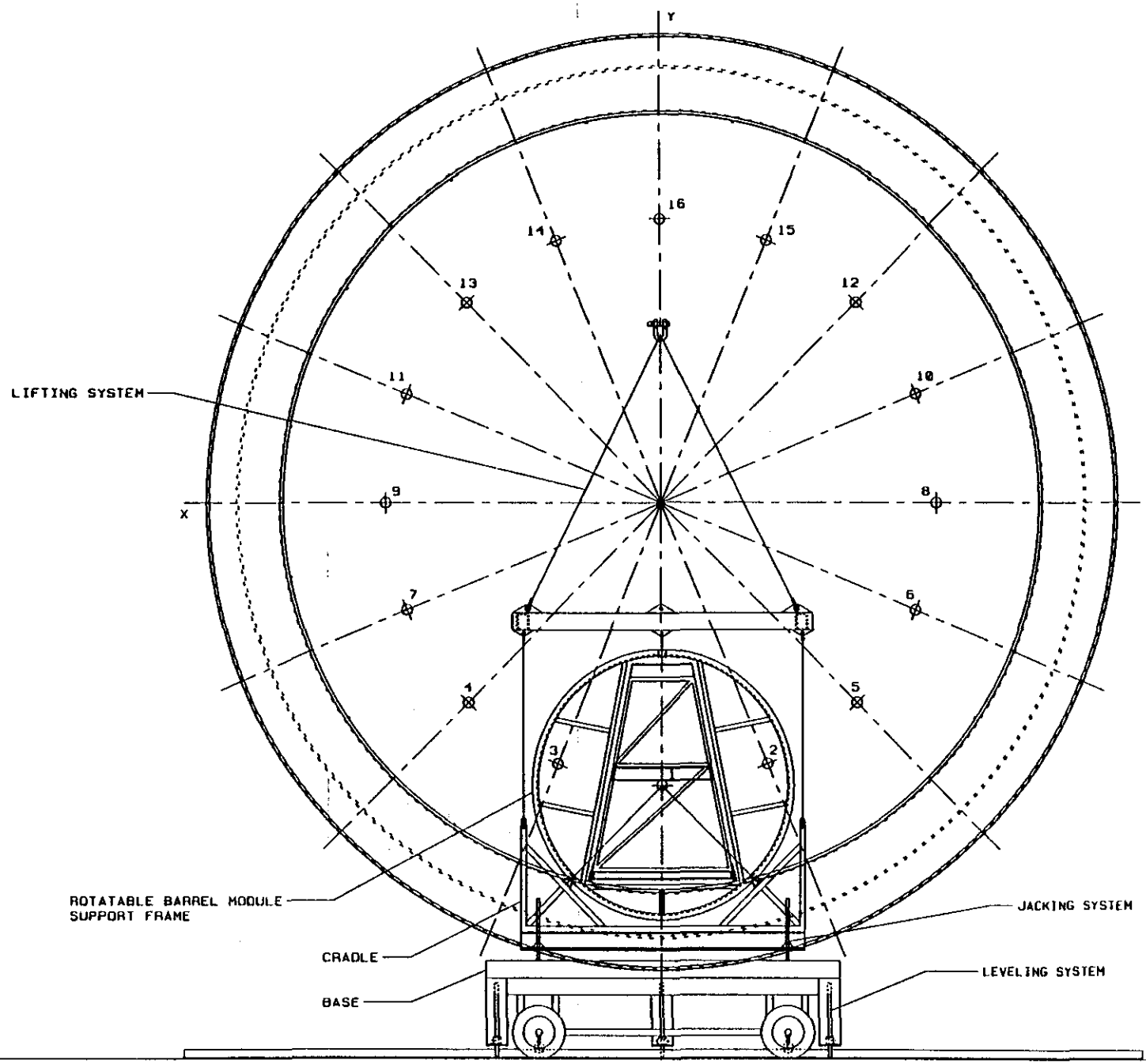



GEM ENDCAP MUON
(2 MODULE ASSEMBLY)

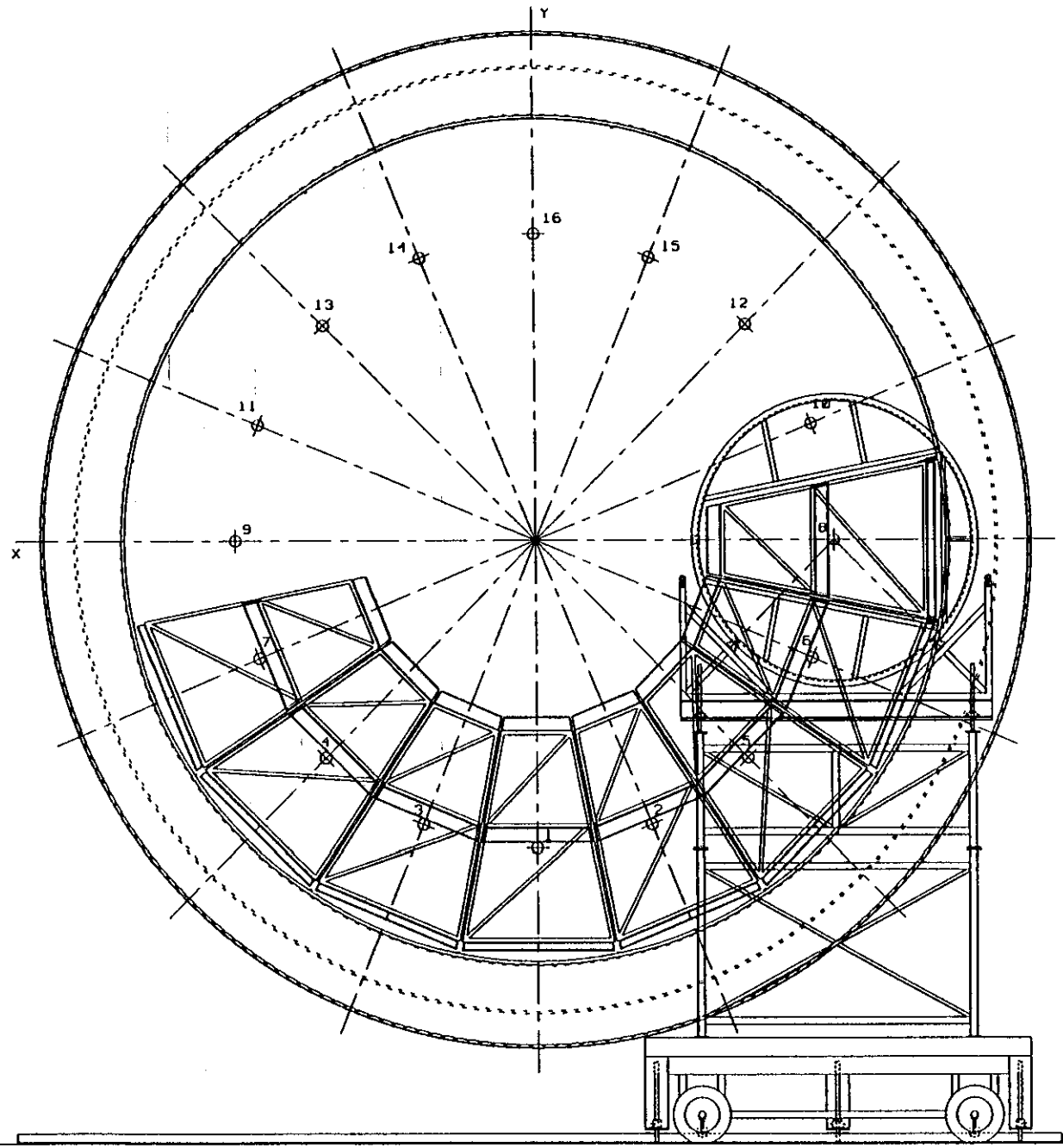
BARREL REGION INSTALLATION
(ELEVATION VIEW)



BARREL REGION INSTALLATION
(MODULE IN FRAME LOWERED ONTO INSTALLATION FIXTURE)



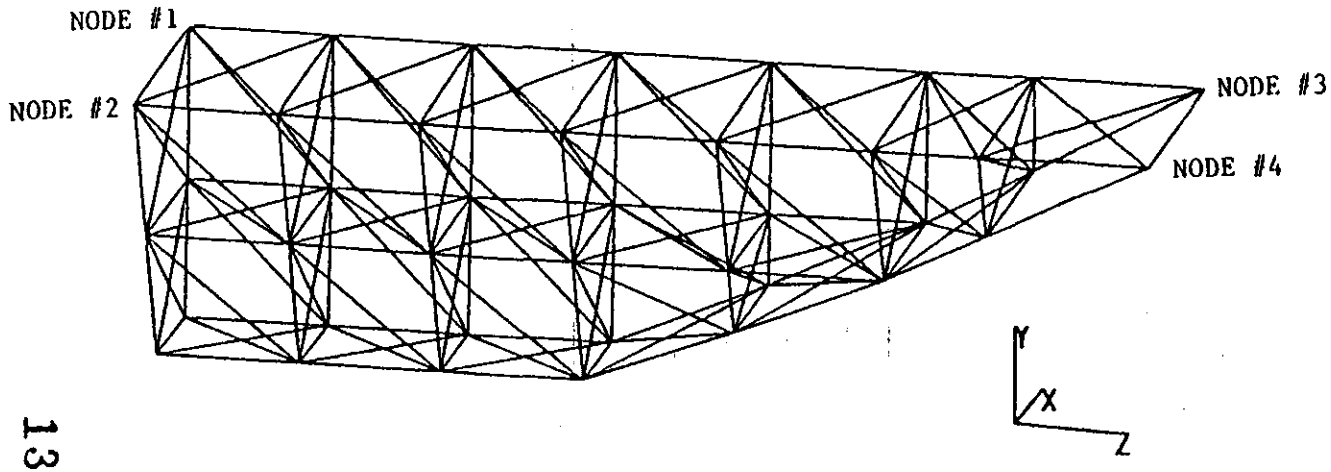
BARREL REGION INSTALLATION
(3-O'CLOCK POSITION)



G.E.M.

BARREL REGION

01 July 1992

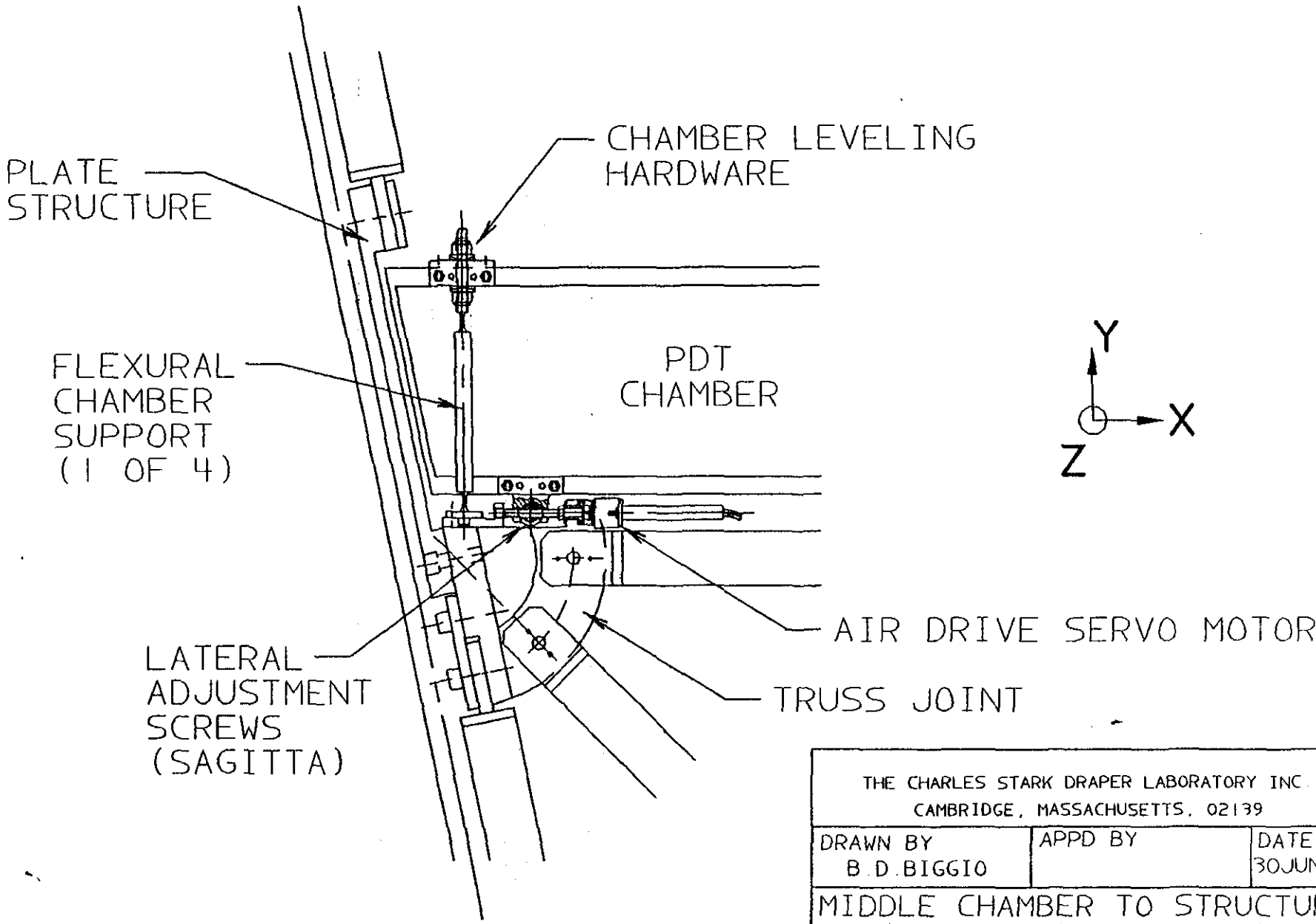


NODE #1 X,Y,Z CONSTRAINED
NODE #2 Y,Z CONSTRAINED
NODE #3 X,Y CONSTRAINED
NODE #4 Y CONSTRAINED

- Results Summary
  - maximum deflection 5.0 mm
  - minimum stress safety factor of 13.5 relative to yield
  - maximum force ≈ 2.48E4 N
  - buckling safety factor design criterion minimum of 5
  - global fn > 7 Hz
  - lowest member fn ≈ 12 Hz

F. Taylor

DRAPER LABORATORY



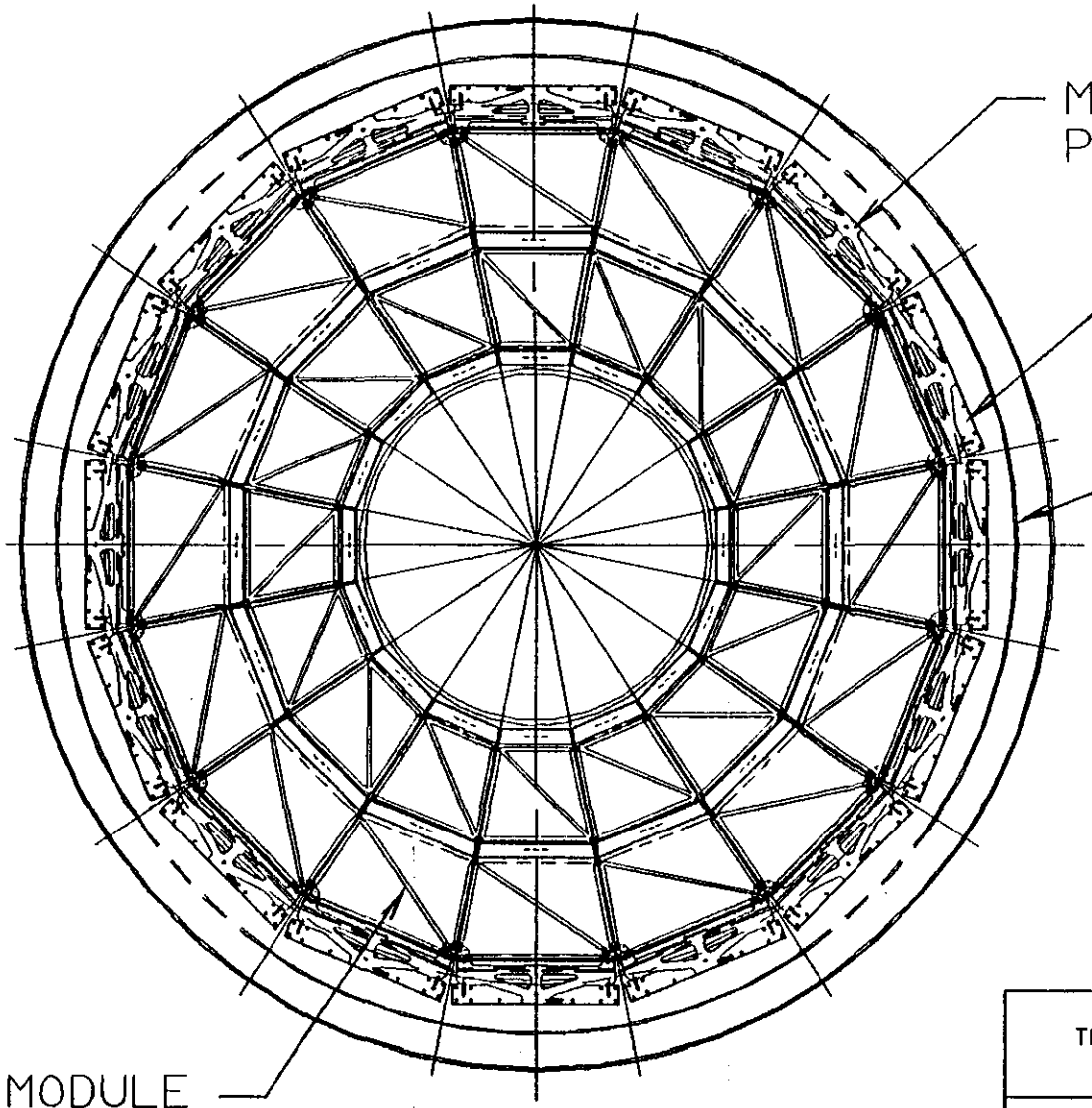
THE CHARLES STARK DRAPER LABORATORY INC
CAMBRIDGE, MASSACHUSETTS, 02139

DRAWN BY	APPD BY	DATE
B.D.BIGGIO		30JUN92

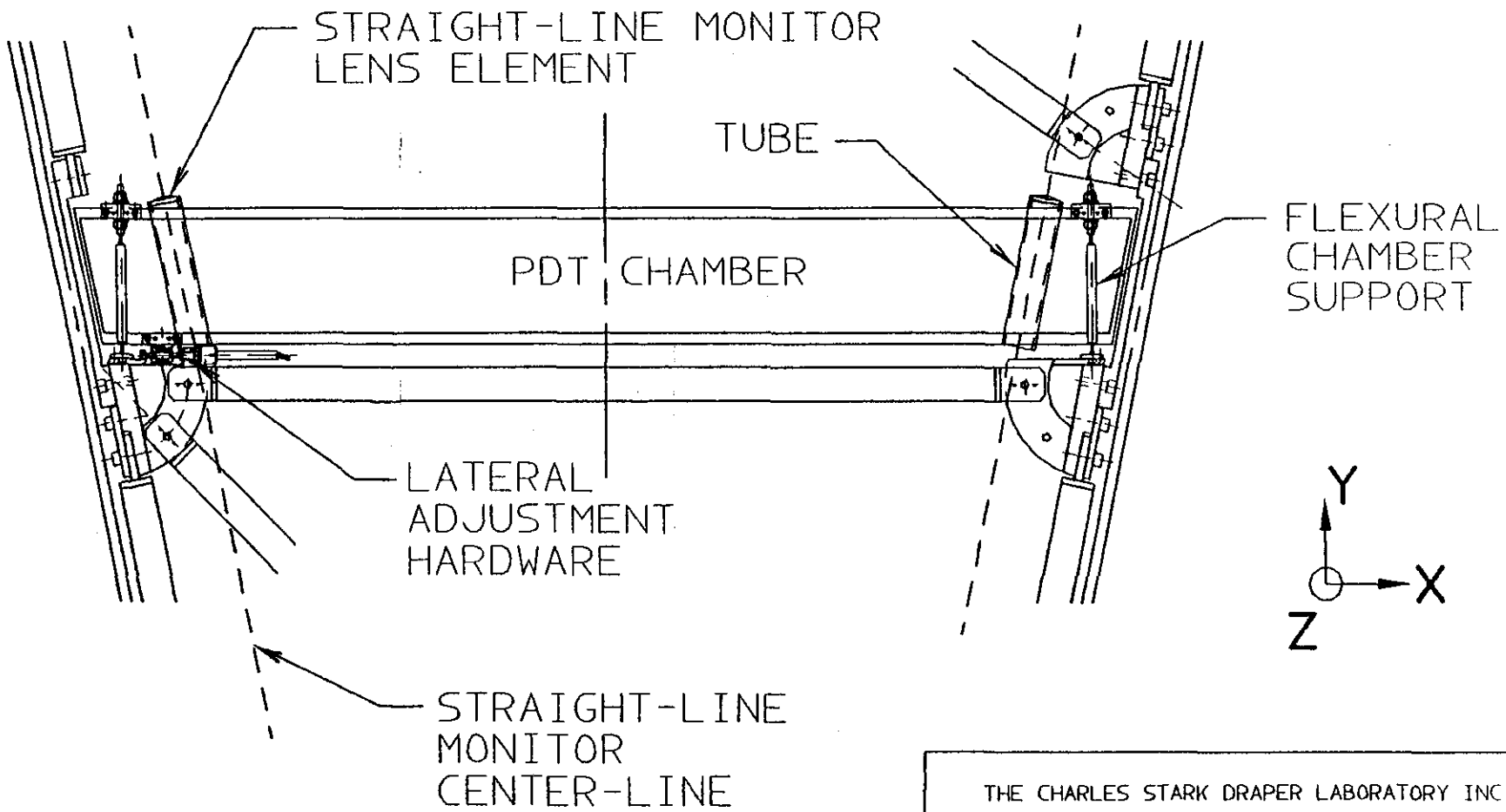
MIDDLE CHAMBER TO STRUCTURE (INTERFACE HARDWARE)

SIZE	FSCM NO.	DRAWING NO.	REV
A	51993	292929-01	–

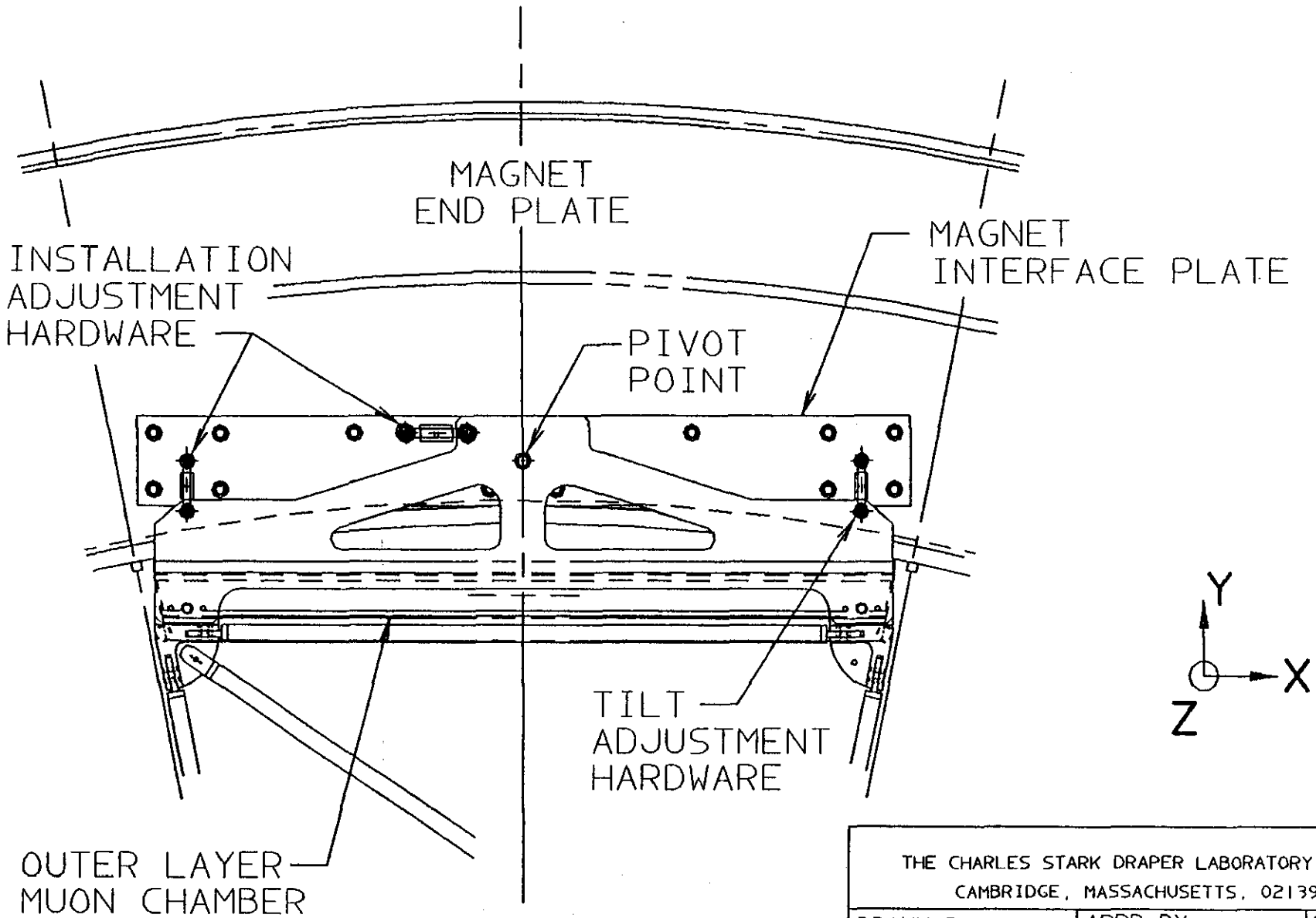
SCALE NONE | SHEET 1 OF



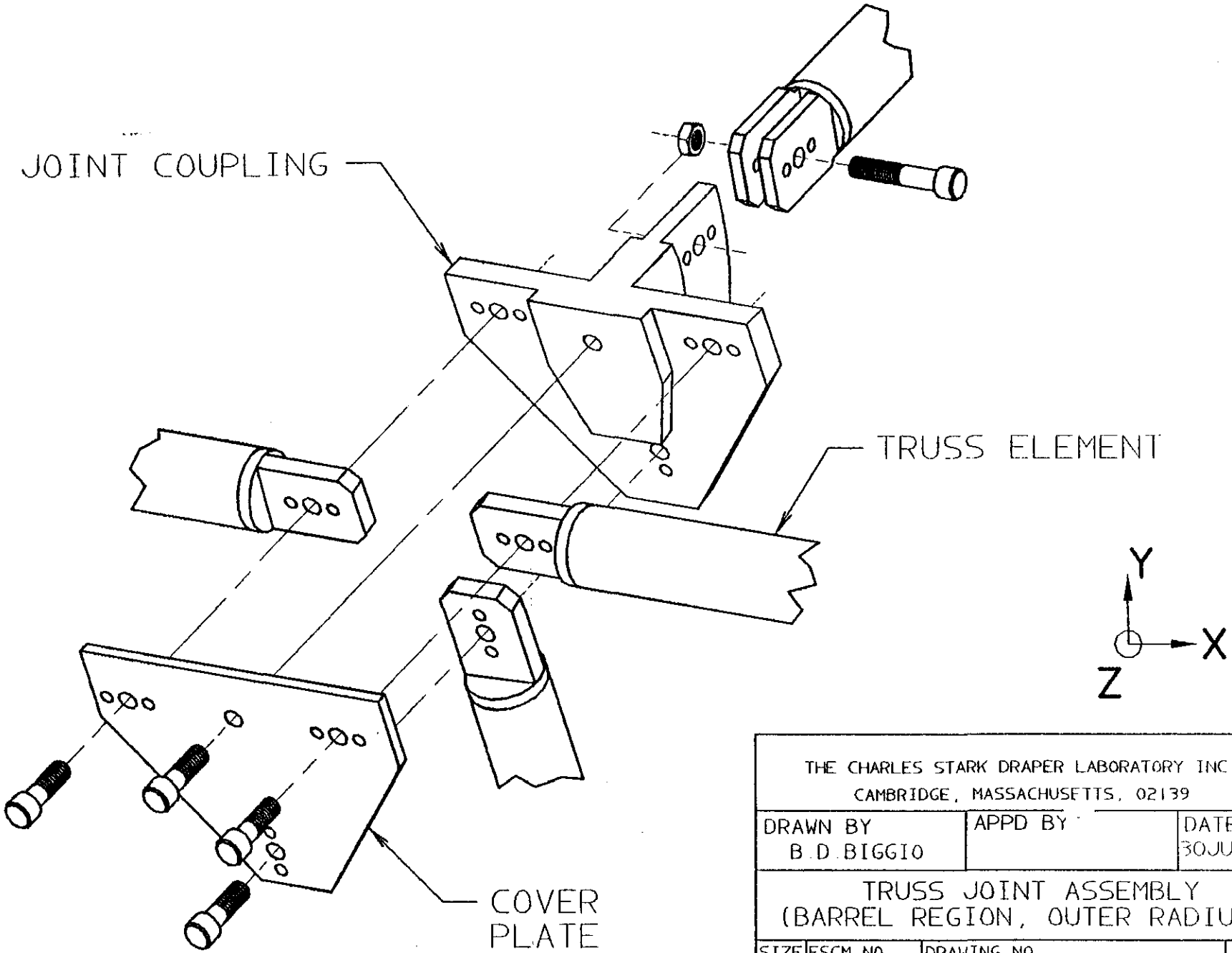
THE CHARLES STARK DRAPER LABORATORY INC. CAMBRIDGE, MASSACHUSETTS, 02139		
DRAWN BY B.D.BIGGIO	APPD BY	DATE 30JUN92
GEM BARREL REGION MUON SYSTEM (END VIEW)		
SIZE A / FSCM NO. 51993	DRAWING NO. 292932-01	REV -
SCALE NONE		SHEET 1 OF



THE CHARLES STARK DRAPER LABORATORY INC CAMBRIDGE, MASSACHUSETTS, 02139		
DRAWN BY B.D.BIGGIO	APPD BY	DATE 30JUN92
MIDDLE CHAMBER/STRUCTURE ASSY (BARREL REGION-PDT CHAMBERS) ALIGNMENT LINES ON MEMBRANE END		
SIZE A	FSCM NO. 51993	DRAWING NO. 292929-02	REV -
SCALE NONE		SHEET 1 OF



THE CHARLES STARK DRAPER LABORATORY INC. CAMBRIDGE, MASSACHUSETTS, 02139		
DRAWN BY B.D.BIGGIO	APPD BY	DATE 30JUN92
INTERFACE HARDWARE (MAGNET/BARREL MUON MODULE)		
SIZE A / FSCM NO. 51993	DRAWING NO. 292932-02	REV –
SCALE NONE		SHEET 1 OF



THE CHARLES STARK DRAPER LABORATORY INC CAMBRIDGE, MASSACHUSETTS, 02139		
DRAWN BY B.D.BIGGIO	APPD BY	DATE 30JUN92
TRUSS JOINT ASSEMBLY (BARREL REGION, OUTER RADIUS)		

SIZE	FSCM NO.	DRAWING NO.	REV
A	51993	292929-03	-
SCALE NONE		SHEET 1 OF	

ALTERNATIVE TRIGGER SCHEME

L. Barabash

A GENERATION OF MUON TRIGGER USING SIGNALS FROM GEM-PRECISE SLOW DRIFT DETECTORS

M.Atiya, L.Barabash, C.Bromberg, Yu.Fisyak, N.Lau, D.Marlow, R.Miller, G.Mitselmakher, F.Stocker, V.Zhukov

April 15, 1992

Abstract

One a possible version of muon trigger shaping for the GEM muon system is discussed. It requires specific ϕ no orientation of the drift tubes and allows measurement of the absolute time of flight through slow detectors (a drift time more than a distance between beam bunches).

1 Description of Algorithm of the Absolute Time of Flight Measurements

As known, an absolute time of flight of particles through the drift detectors can be calculated using three drift gaps as shown at the fig.1. It shows the space picture where (W_1,W_2,W_3) are sensitive wires and time information registrated from sense wires (T_1,T_2,T_3). We would like to emphasize the interesting feature of the drift times situation which have the symmetry around the time equal to $T_{tot}/2$, if we compare the drift time T_2 with calculated coordinate $(T_1 + T_3)/2$. This circumstance can be used for calculation of the absolute time of flight of particle through the detector sensitive volumes provided that a drift velocity and a total drift time T_{tot} should be known.

If a trigger is absent we can measure the time intervals between the wire pulses and using a property of picture symmetry calculate unknown quantities with take account a correction to the time of the estimation of situation. In result, we can obtain a value of x, a time interval from last pulse to the end of full drift time.

The figure 2 shows some different time situations generated a particle into drift gaps. The first three pictures describe the situations when a muon track don't cross the bounds of three half-cells ("simple case"). In this instance, the x parameter can be found from relation ("Solution 1"):

$$x = \frac{T_{tot}}{2} - \left(\frac{t_1}{2} + \frac{t_2}{4}\right)$$

More complex situation is arisen in the instance, when muon track pass through the bounds of a simple case. We obtain for this events three additional relations covered different angle ranges.

Solution 2 describes the angles from 0° to $5,5^o$ in area near a boundary of the first and third layers of tubes (see fig.3.a).

$$x = \frac{t_2}{2} - t_1 \qquad (2)$$

Solutions 3 (fig.3.b) and 4 (fig.3.c) cover the angles up to 16°.

$$x = T_{tot} - \left(t_1 + \frac{t_2}{2}\right) \qquad (3)$$

$$x = \frac{t_2}{2} \qquad (4)$$

where x is time interval from the time of the last pulse from the third layers to time of trigger generation.

The fig.3 shows three layers of drift tubes and marks the areas which are provided different solutions.

The maximum angle is defined by the size of the GEM muon detectors equal to 11°. Suggested method provides the trigger for muon bending angle to 5° and corresponds with momenta of muon more than 10 Gev/c for single triplet of detector layers. Using of the fourth layer allows to widen the angle range up to 30°.

2 The estimation of efficiency

The main processes which define a trigger efficiency are a birth of δ-ray into gas filling and bremsstrahlung of high energy muons in a calorimeter and muon detector walls. Besides, we should take account additional background processes such as punchthrough particles, background from low energy neutrons and own noise of the detectors. These processes should be simulate attentively. We would like to do the next comment to taking into account these processes. When we use the probabilities of these processes for calculation of efficiency of drift detectors for realization of this suggestion we should divide ones per 2, because we interest the first pulse and in 50% of cases it is muon track (see fig.4.). Besides, the presence of magnetic field allows to hope an additional regection these background processes.

Estimate an admissible level of noise from separate drift tube in suggestion what only twofold coincidence used for generation of trigger (second and third superlayers of the GEM muon system). We believe what the number of a random coincidence not more

than one percent (one noise pulse per t=1μs x 100)

$$N_r = \tau N_{2s}^2 \quad (\tau = 1\mu s)$$

We obtain from here

$$N_{2s} = 10^5 = 6N_i$$

per second and

$$N_i = 1.7 \times 10^4$$

per second for drift tube layers into triplet. This allows to define the number of drift tubes into triplet.

If we use all three superlayers of muon system ($N_r = 2\tau^2 N_{3s}^3$):

$$N_i = 3 \times 10^4$$

The main dangerous for this scheme is false triggers. In any case we analyse four equations and obtain one right trigger pulse and three false pulses. The first decision, coincidence with accelerator frequency with time resolution about (8-10) nsec, should reduce this count significantly. Further redaction of the false trigger level can be done a comparison of the bending muon angles for different superlayers (see fig.1, $\phi = f(t_2^1 - t_2^2) = f(t_2^2 - t_2^3)$, where t_2^i are the time intervals t_2 for 1,2 and 3 superlayers of barrel system).

The fig.5. shows the possible way of electronic realization this idea using the fast addition registers for solution 1. Analyse of the another solutions can be done similar solution 1. Using this way we can make corrections of x-value on unlinearity of the characteristics of detectors and delays defined the length of wires (the second coordinate). All these corrections can be done very fast.

We don't discuss here the electronic control scheme. Obviously, it should be have high level of an intellect, and task of this article is to try to define the main conditions for this scheme.

This algorithm can be checked during the test of muon detectors. In principle, it should be done "off-line" without additional apparatus. Using the measured coordinates T_1,T_2,T_3 we can obtain time intervals t_1, t_2 and after calculation value of x investigate dependence T_{tot} from coordinates and angles of tracks.

Measurement of t_1, t_2 and x will be more interest desicion.

The fig.6. explains this possibility. The three time intervals should be measured in this case. We should compare measured value of x with calculated value using different solutions. It allows to check suggested possibility of generation moun trigger.

3 Referencies

1. Lanev A.V.,Preprint IHEP 89-145, Protvino, 1989 (in Russian)

4 Figure options

Fig.1. The principle of the muon trigger generation.

Fig.2. The different situations arising into drift tubes ("simple case")

Fig.3. a,b,c) - The angle ranges covered the different solutions.
Fig.4. A muon track and δ - ray tracks into drift tube.

Fig.5. The sketch of the electronic fast decision scheme.

Fig.6. The time pictures of the checking of suggested algorithm.

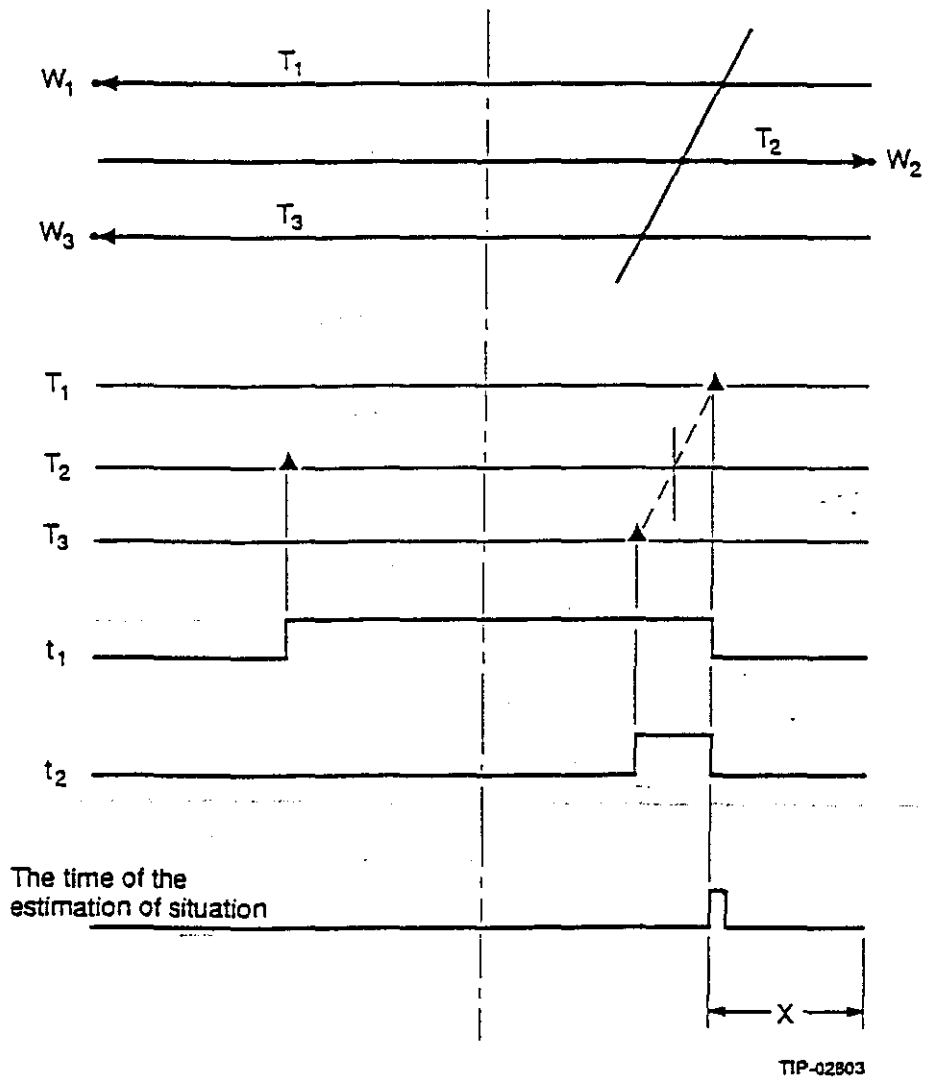
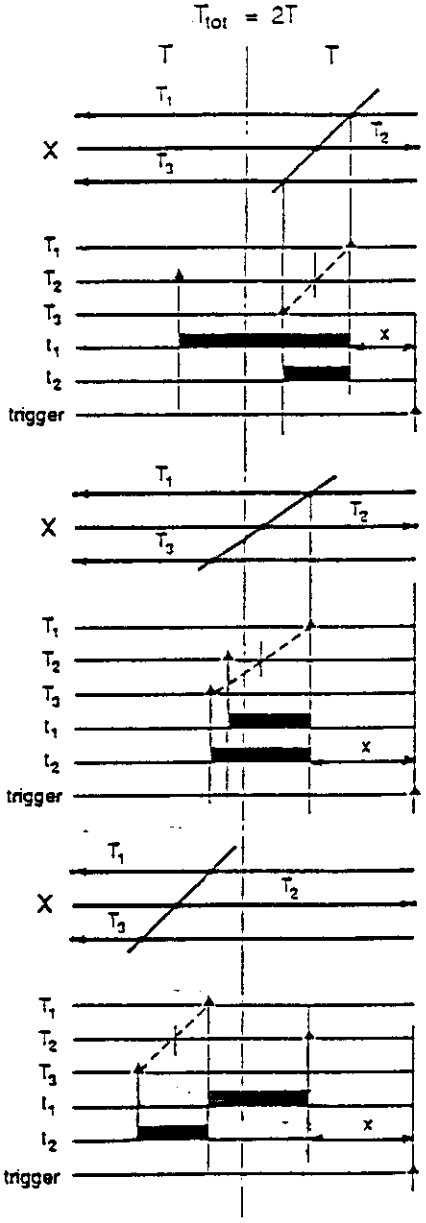

W1
T1
T2
W2
W3
T3
T1
T2
T3
t1
t2
The time of the
estimation of situation
X
TIP-02803

Fig.1.



$$x = T - \left(\frac{t_1}{2} + \frac{t_2}{4}\right)$$

$$x = T - \left(\frac{t_1}{2} + \frac{t_2}{4}\right)$$

$$x = T - \left(\frac{t_1}{2} + \frac{t_2}{4}\right)$$

Fig.2.

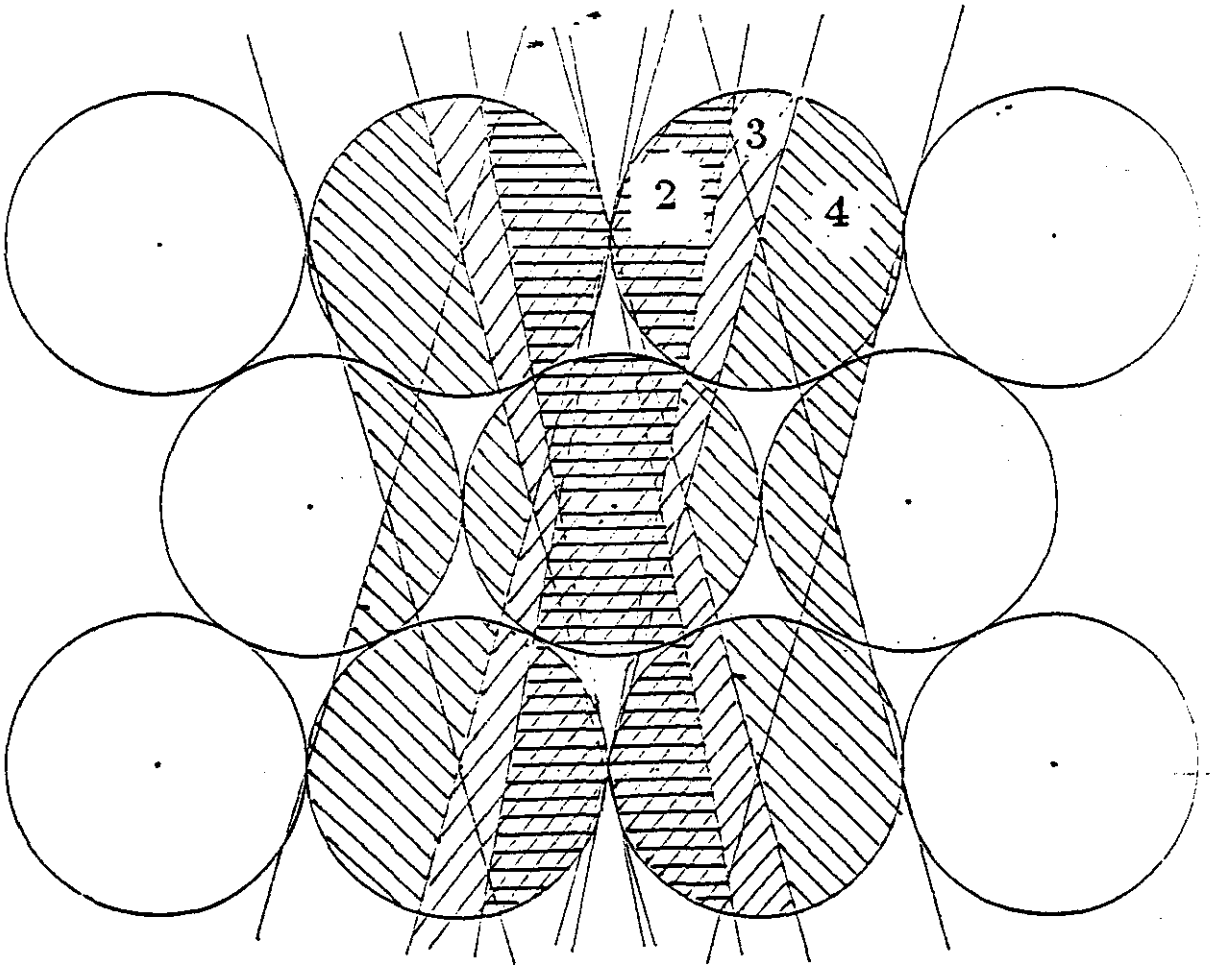
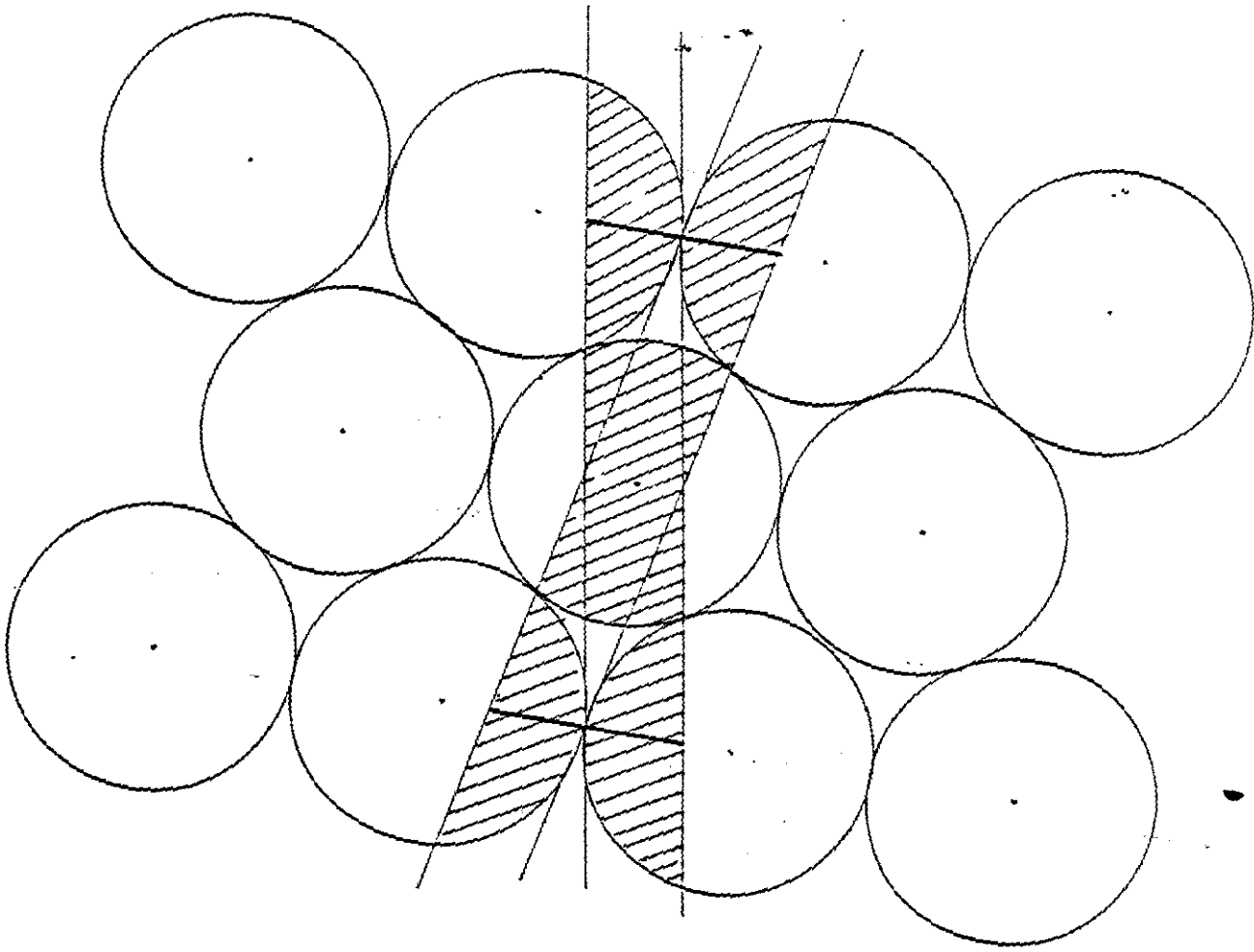


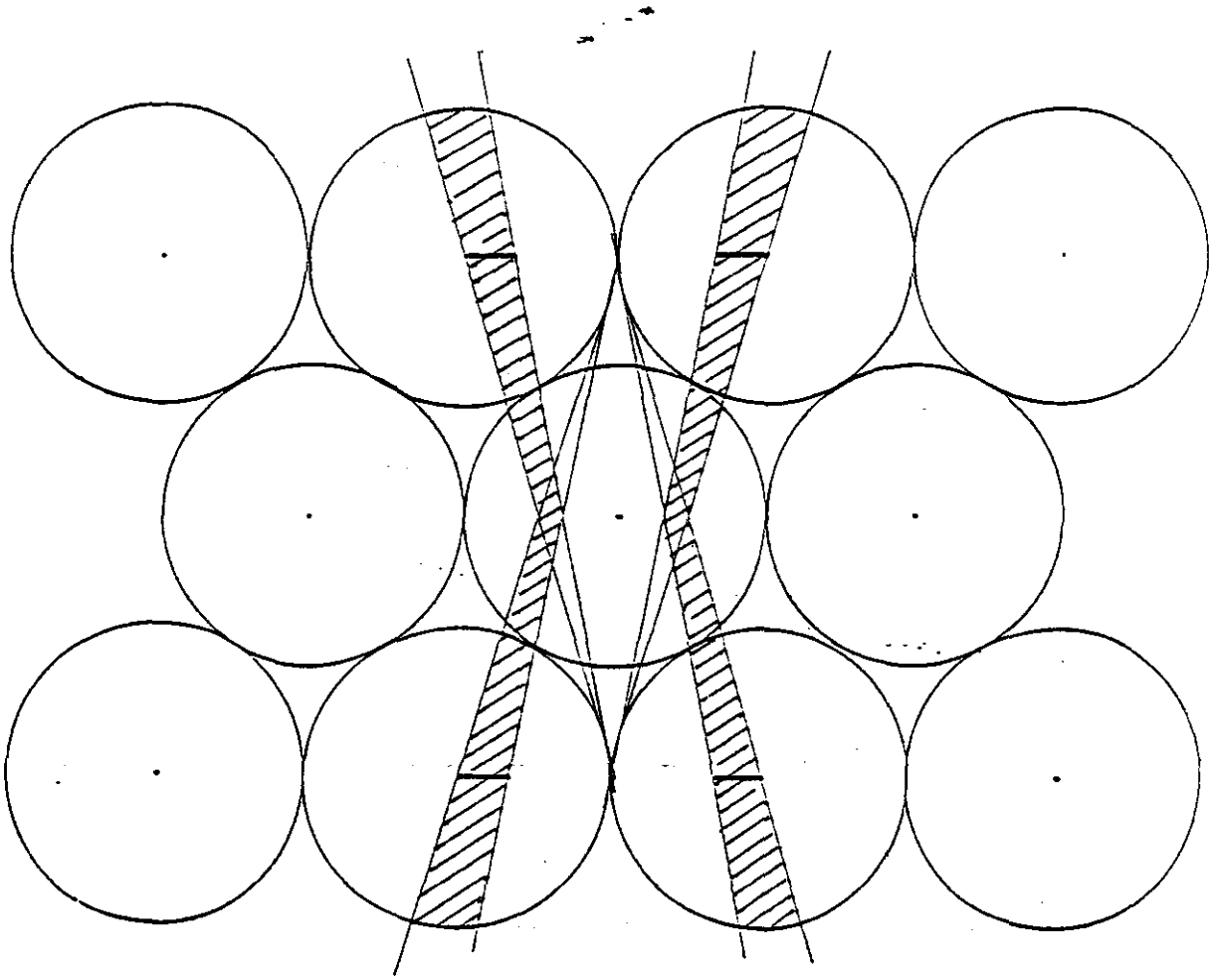
Fig.3.



Solution 2:

$$x = \frac{t_2}{2} - t_1$$

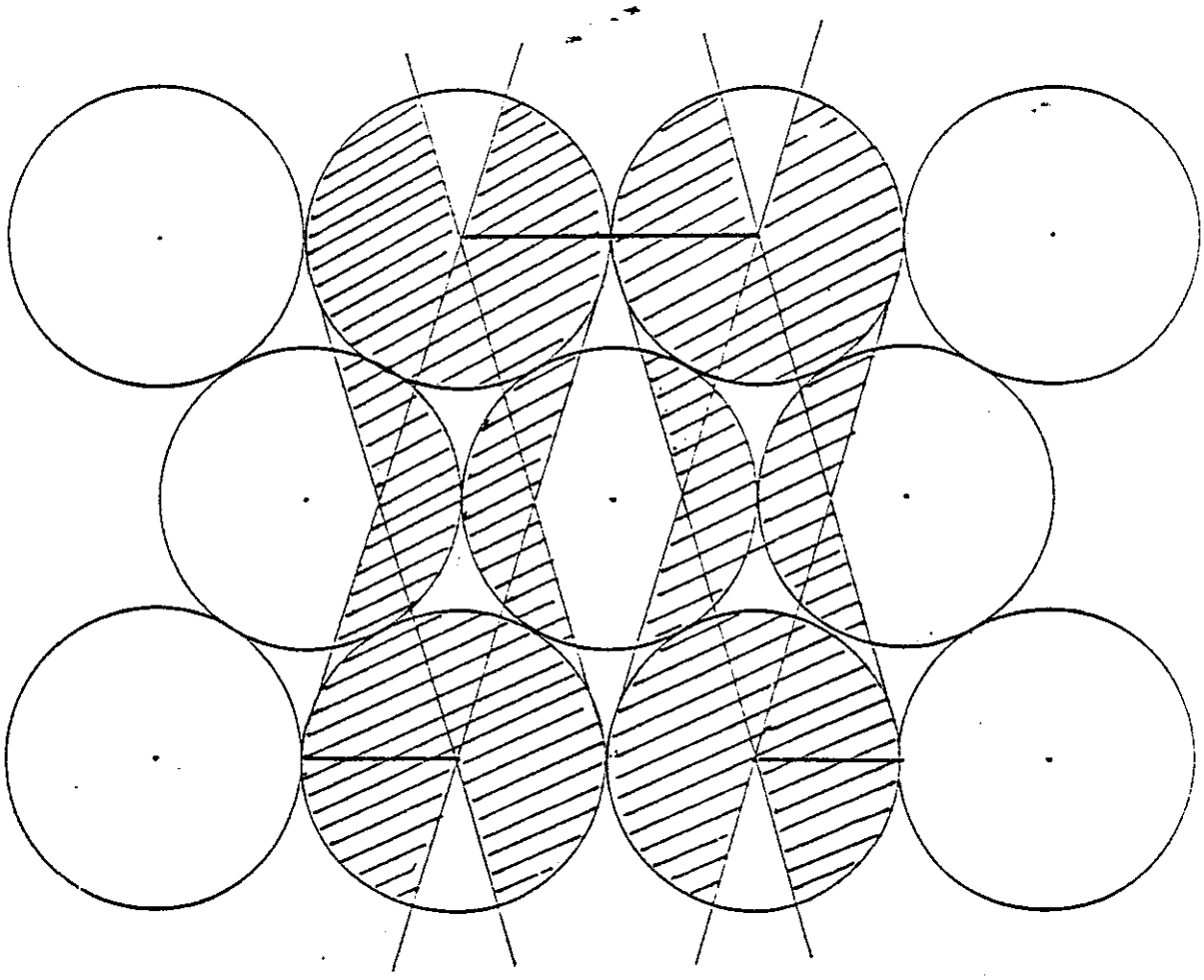
Fig.3.a.



Solution 3:

$$x = T_{tot} - \left(t_1 + \frac{t_2}{2}\right)$$

Fig.3.b.



Solution 4:

$$x = \frac{t_2}{2}$$

Fig.3.c.

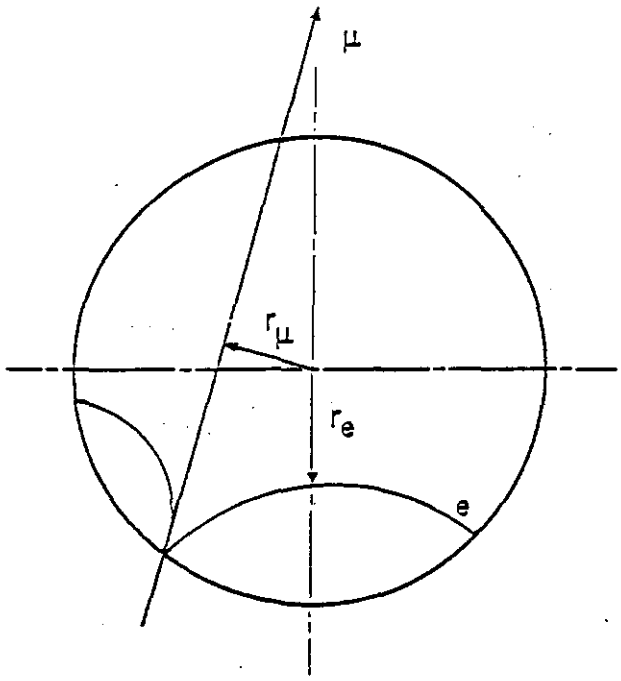


Fig.4.

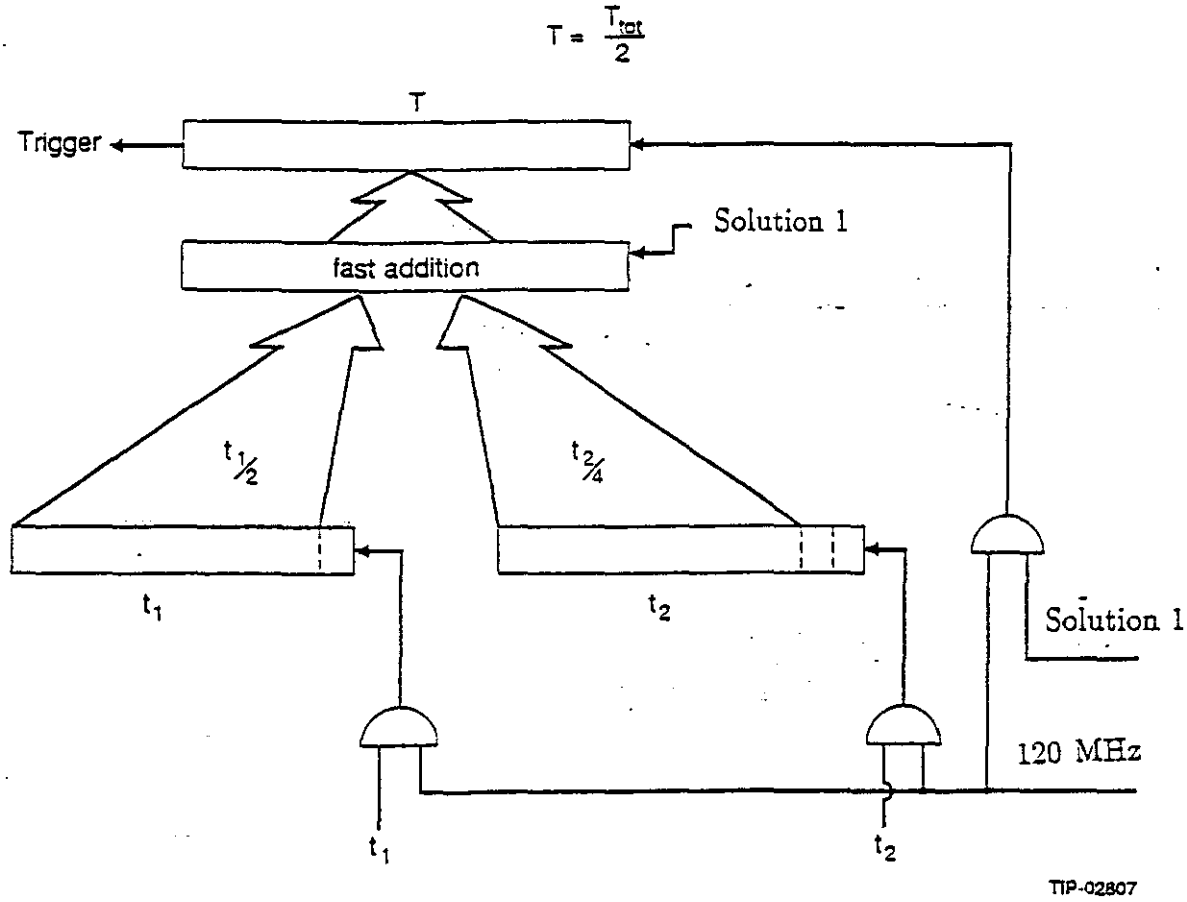

T = Ttot/2
T
Trigger
Solution 1
fast addition
t1/2
t2/4
t1
t2
Solution 1
120 MHz
t1
t2
TIP-02807

Fig.5.

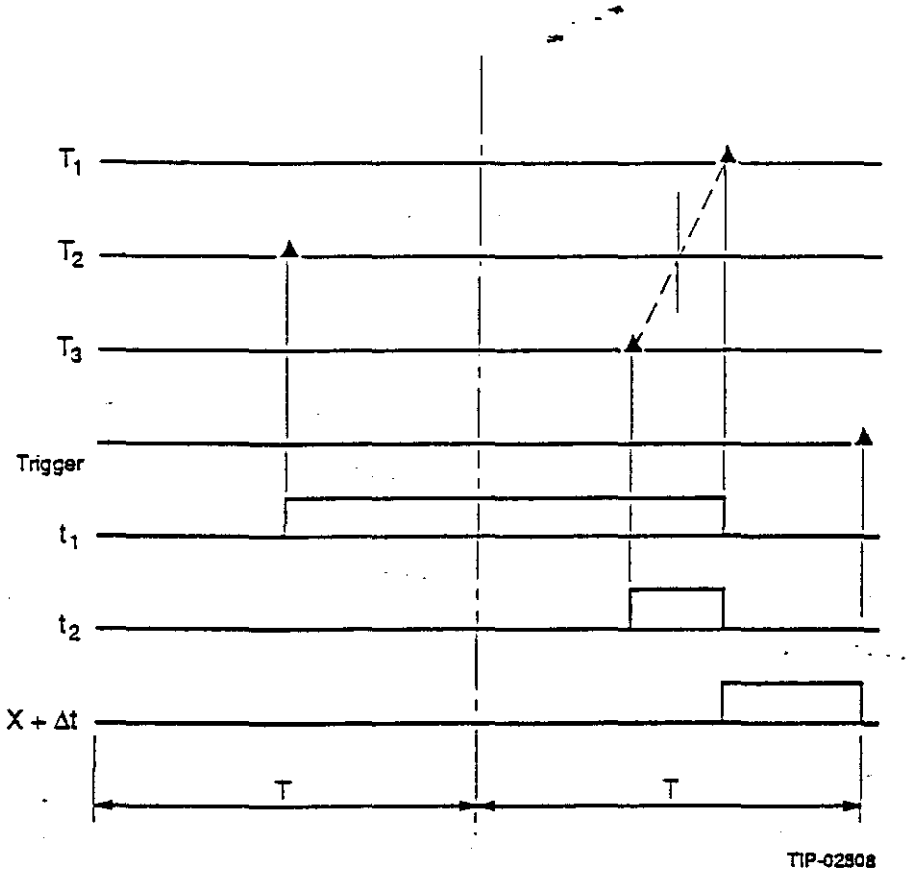
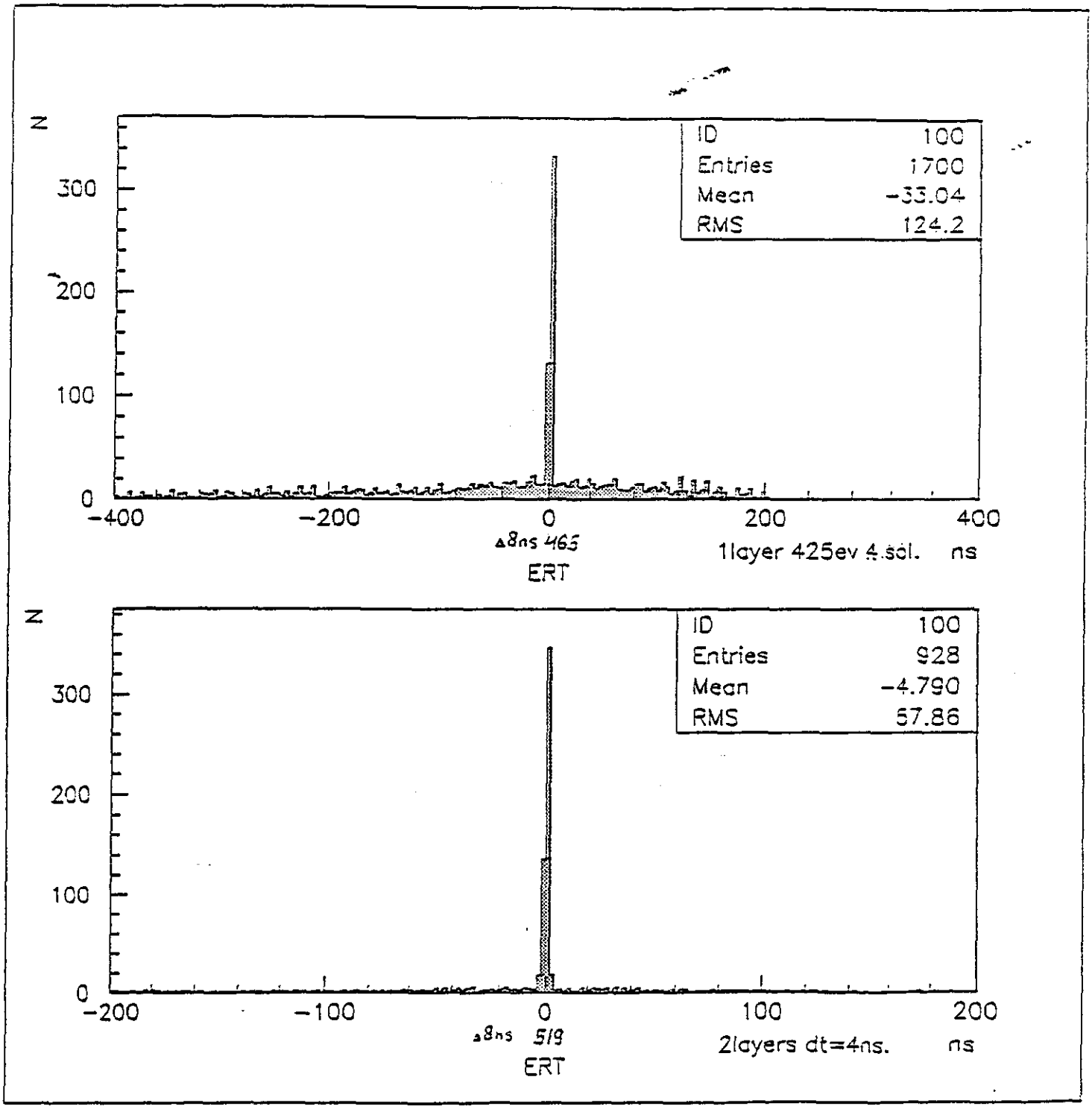
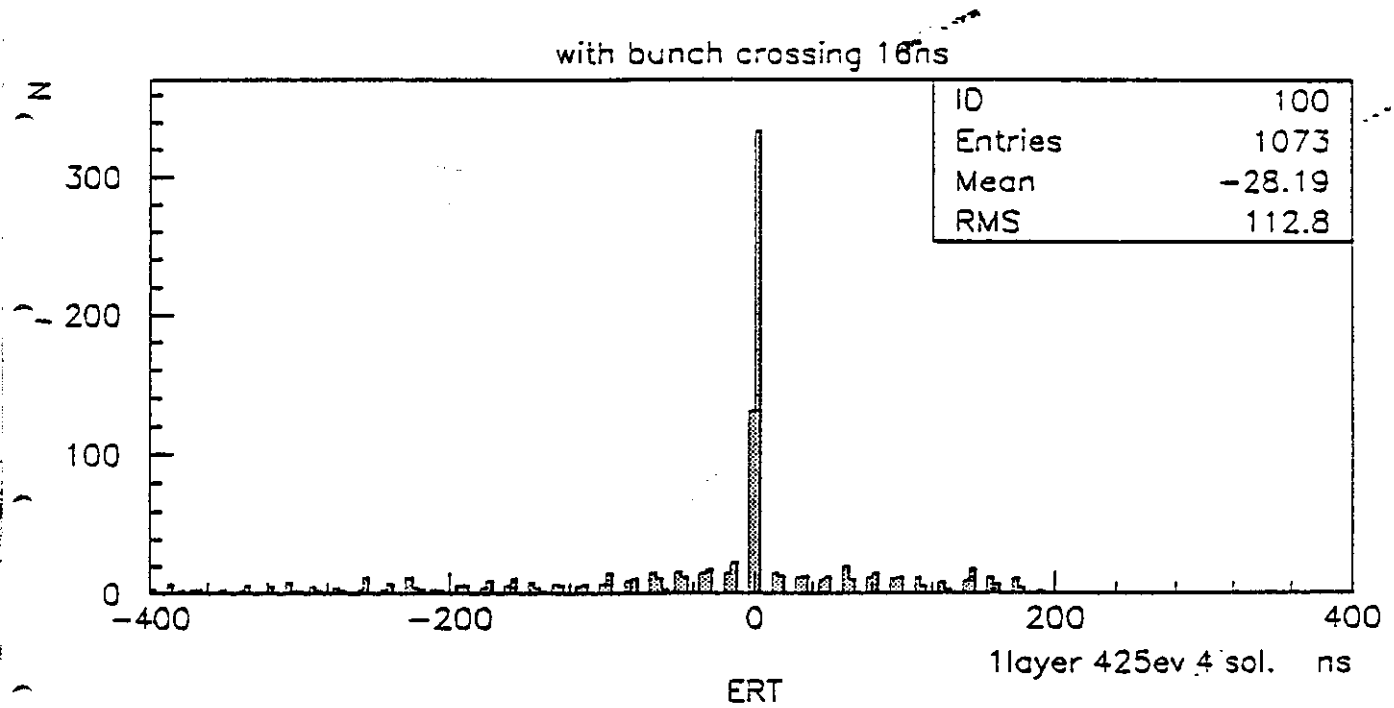
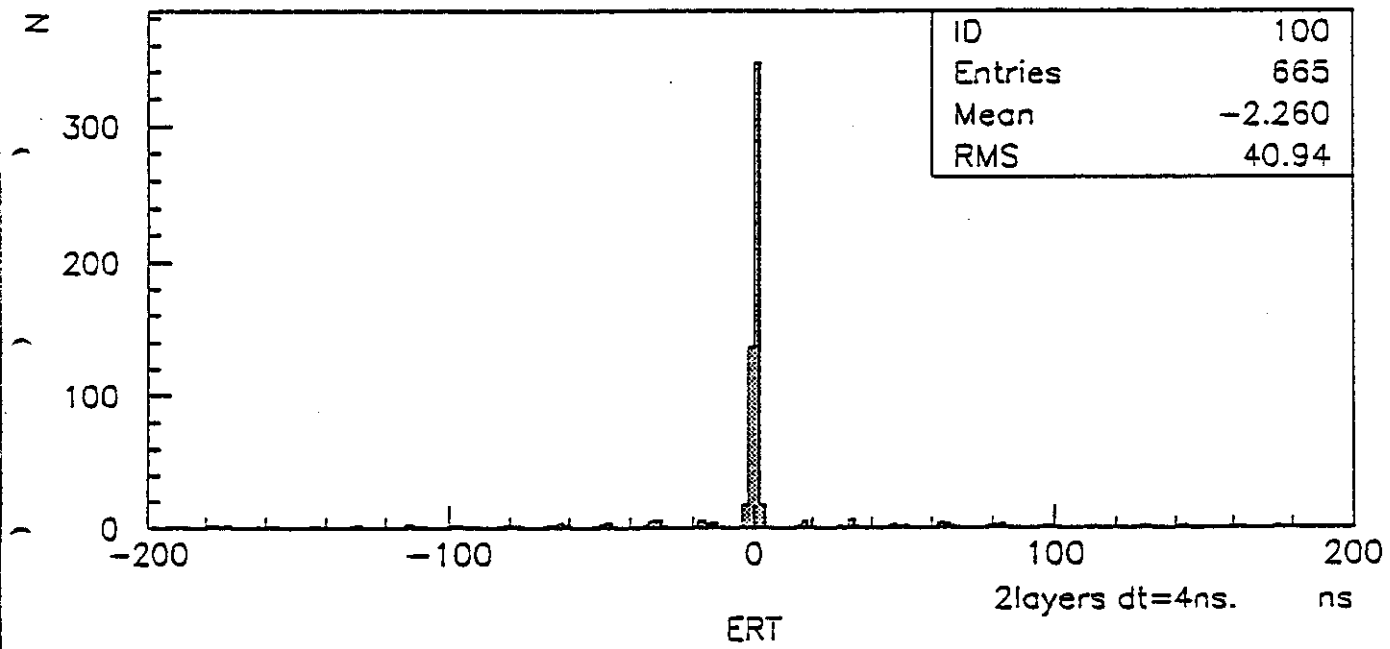


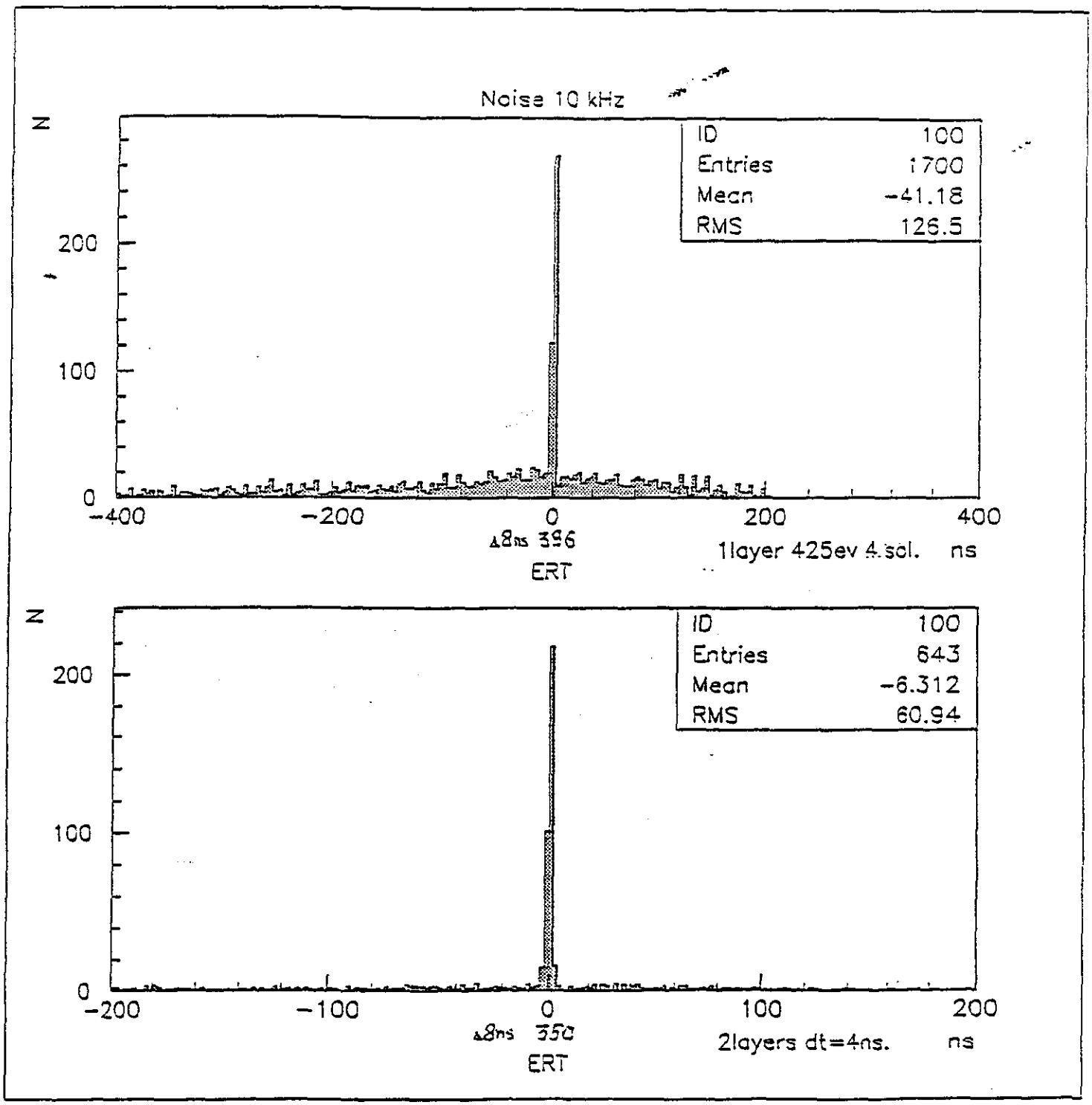
Fig.6.



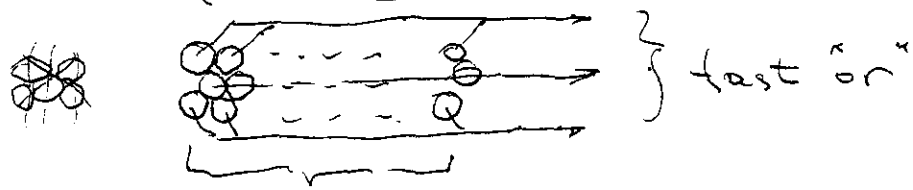
(II ← and → III) Layers of the GEM muon system


with bunch crossing 16ns
N
ID 100
Entries 1073
Mean −28.19
RMS 112.8
300
200
100
0
−400
−200
0
200
400
1layer 425ev 4 sol.
ns
ERT


N
ID 100
Entries 665
Mean −2.260
RMS 40.94
300
200
100
0
−200
−100
0
100
200
2layers dt=4ns.
ns
ERT



One set of tubes



32 tubes x 3 = 96 tubes

STATUS OF TRIGGER SIMULATIONS

Maged Atiya

Current status of Trigger Simulation:

1) Full hit-level Monte Carlo Done
(A. Yamashita + Chiaki)

2) Trigger rates & acceptance Done
(Chiaki + Mohammadi)

3) Pattern recognition studies Partial
(A. Yamashita + Atiya) + (Chiaki)

4) Calorimeter depth & rates Done
(Mc Neil)

5) δ rays & muon radiation Partial
(Mc Neil) + (ITEP efforts)

6) neutron rates Partial
(Waters, Wuest, ...)

7) Hardware level simulation of Associative Memory (or similar schemes) Begun
(Murphy + Atiya)

MONTE CARLO STUDIES

A. Golutvin

A. GOLUTVIN
A. OSTAPCHUK
ITEP, Moscow

STUDY OF ELECTROMAGNETIC DEBRIS ACCOMPANYING HIGH MOMENTUM MUONS (WHERE? AND HOW?)

AT ENERGIES ABOVE A FEW HUNDRED GeV RADIATIVE PROCESSES BECOME TO DOMINATE

↳ ASSOCIATED GENERATION OF ELECTROMAGNETIC SHOWERS LEAKING THE CALORIMETER

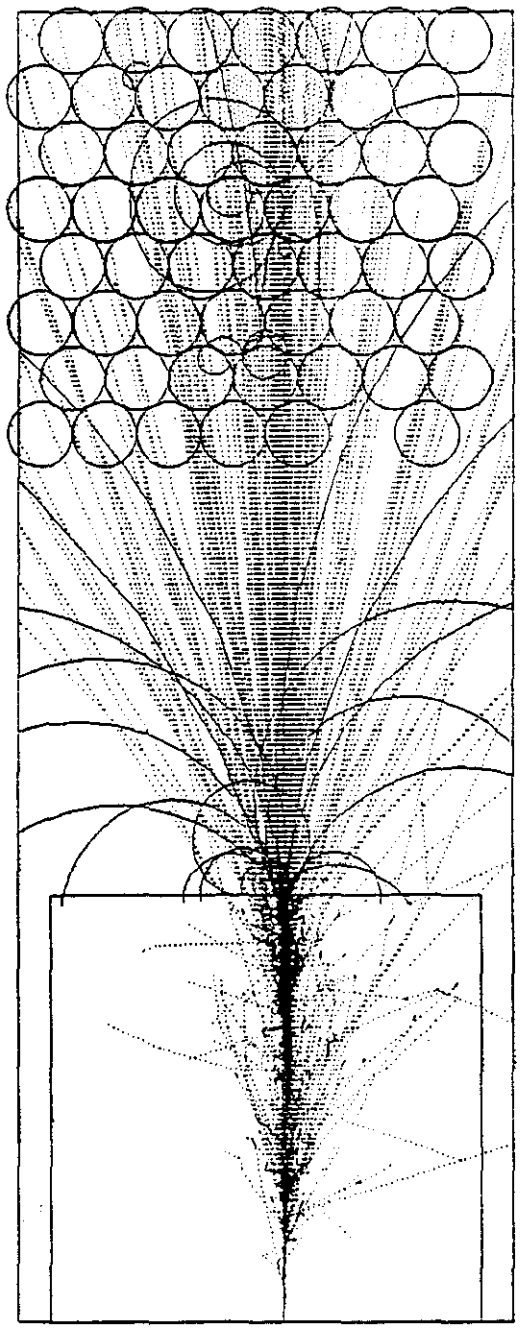
↳ MUON TRACK OBSCURING

FOR HIGH ENERGY MUONS ELECTROMAGNETIC DEBRIS REPRESENT THE MAJOR DIFFICULTY FOR PATTERN RECOGNITION AND PRECISE MOMENTUM MEASUREMENT

IT IS HARD TO SIMULATE AFOREMENTIONED PROCESSES ADEQUATELY

- ELECTROMAGNETIC CASCADES ARE WELL DESCRIBED BY GEANT ONLY UP TO A MINIMUM CUT-OFF ENERGY
- IT IS VERY HARD TO SIMULATE DETECTOR RESPONSE IN REALISTIC CONDITIONS

↳ EXPERIMENTAL STUDIES ARE HIGHLY DESIRABLE



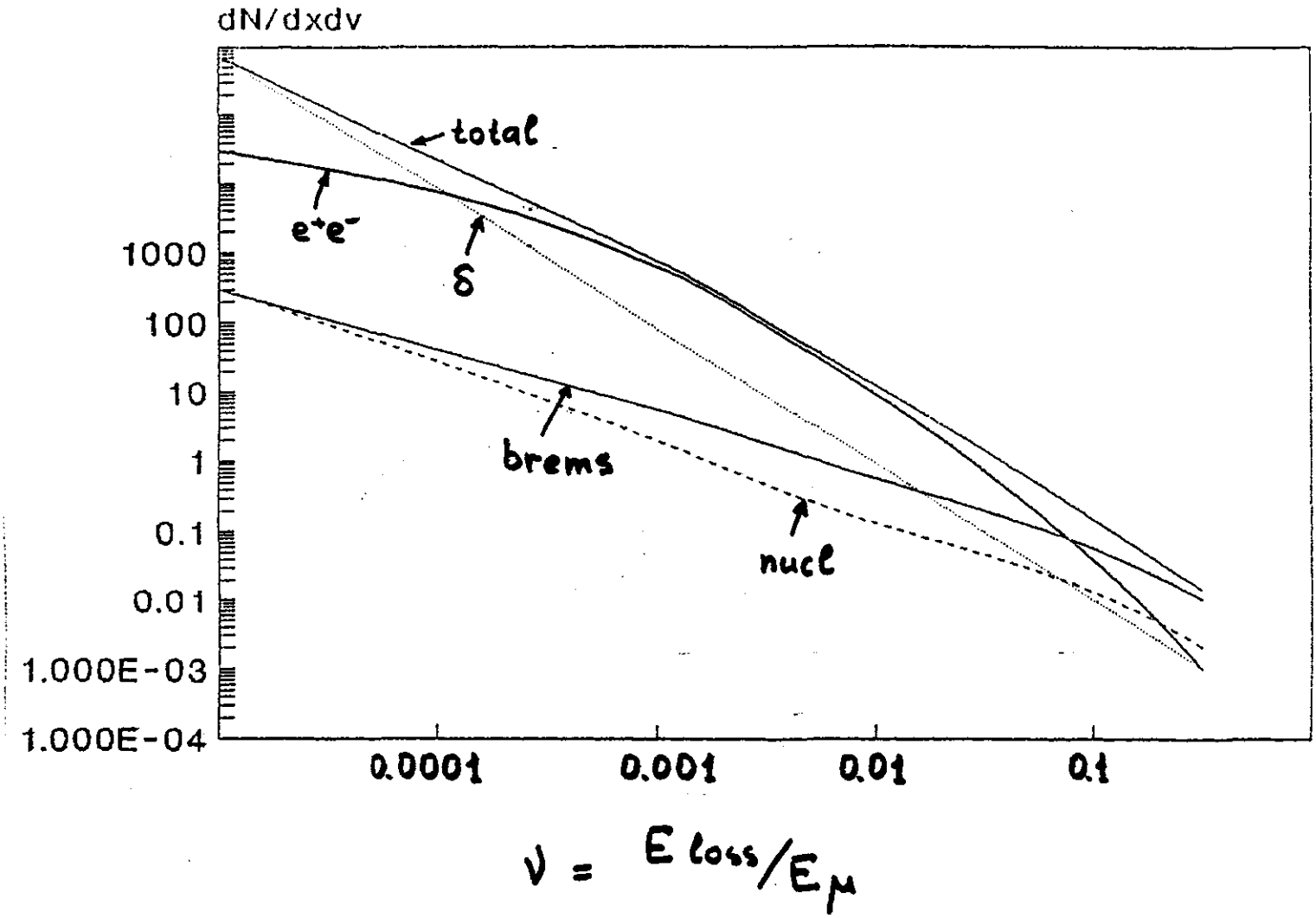
$\langle N_e \rangle \approx 1$

$\langle p_e \rangle = 37$ MeV

$\langle N_\gamma \rangle \approx 7$

$\langle p_\gamma \rangle = 9$ MeV

ENERGY LOSSES OF 1 TeV μ IN Fe



AT HIGH MUON MOMENTUM THE ENERGY LOSSES ARE MAINLY DUE TO:

DIRECT PAIR PRODUCTION
KNOCK ON ELECTRONS
BREMSSTRAHLUNG
NUCLEAR INTERACTIONS

NUMBER OF ADDITIONAL HITS IN MUON DETECTOR

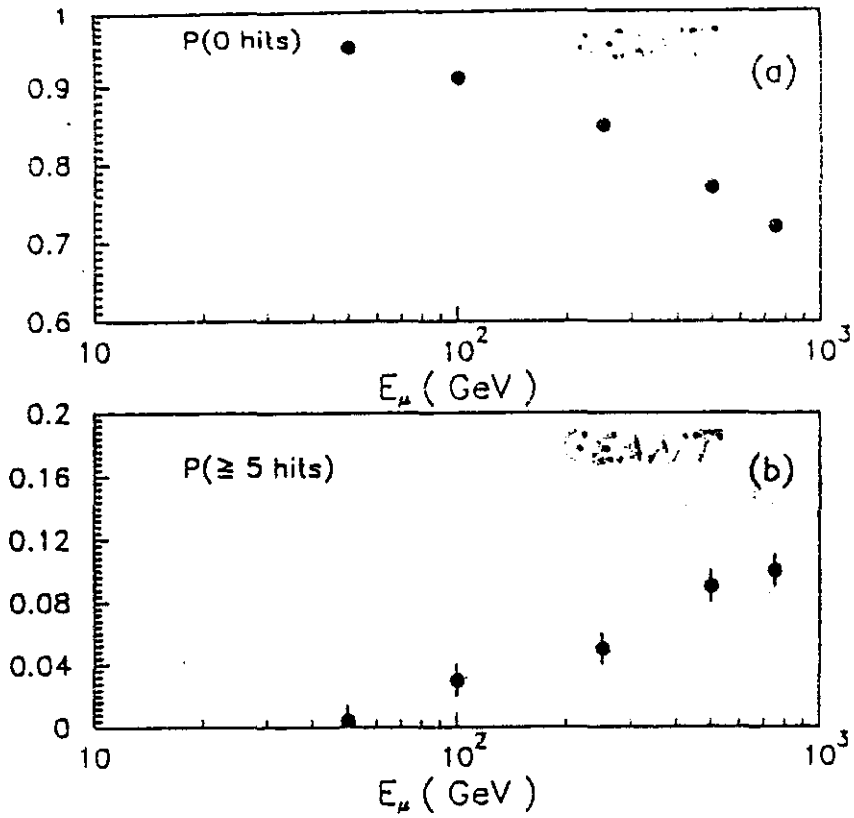


Figure 5: Probability of a clean hit in a detector after 2m of iron (a) as a function of E_μ. The probability of detecting more than 4 hits is plot in (b).

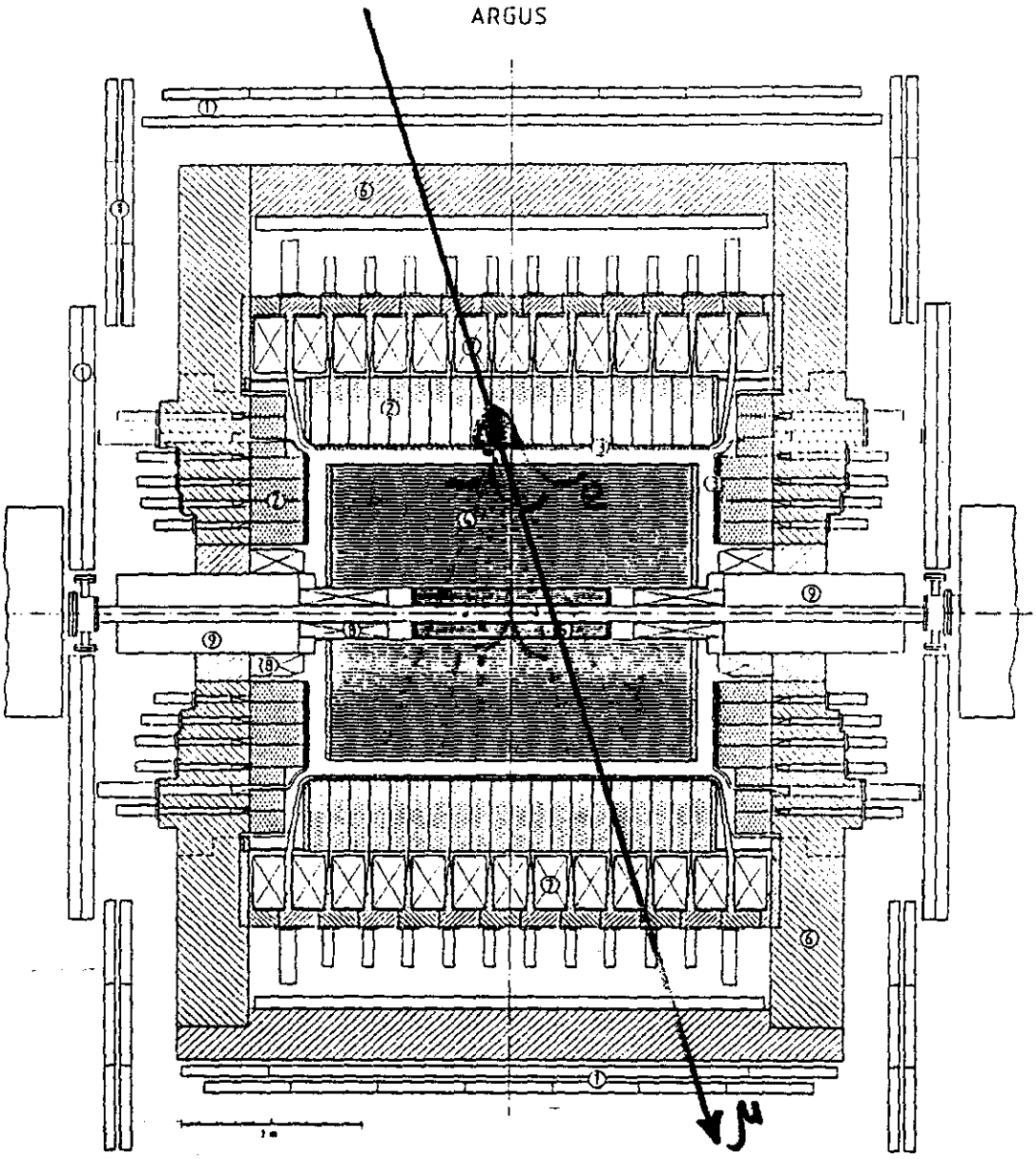
USE μ TEST BEAMS TO VALIDATE MUON-INDUCED SHOWERS AND MUON ENERGY LOSS PRODUCED BY GEANT

NA4: After 2m of iron they observed 0, 1, 2 and ≥ 2 extra hits WITH probabilities 87%, 10%, 2% and 0.5% for muon energies between 20 and 160 GeV; in good agreement with GEANT

Koryotov talk: Initial simulations of μ chambers in
Oct. 17, 91 zero field at FNAL gave encouraging results

RD5 at CERN: Further tests will be done

ARGUS: Test GEANT predictions using high energy cosmic muons

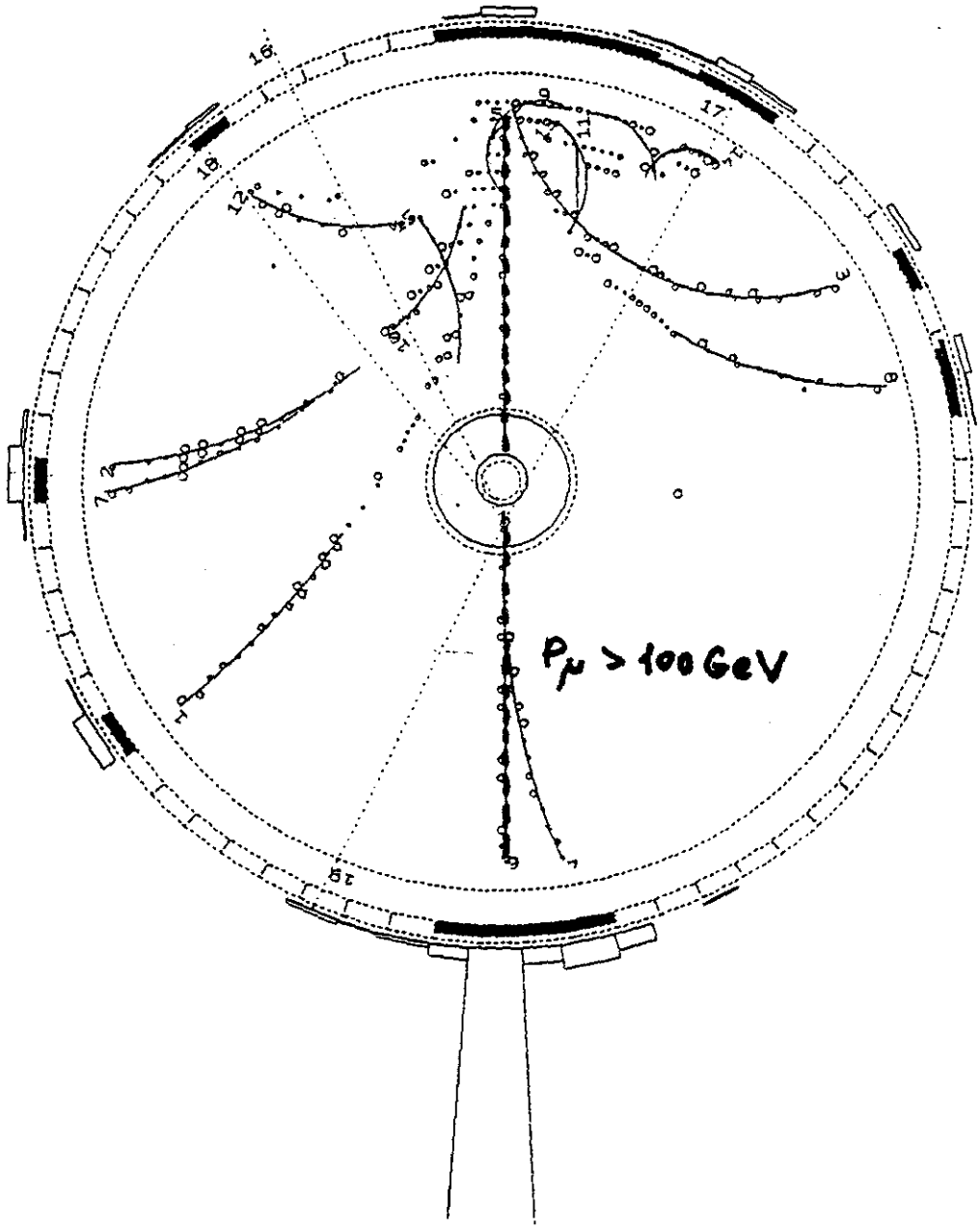


Section through the detector ARGUS parallel to the beam axis. 1: Muon chambers; 2: shower counters; 3: TOF counters; 4: drift chamber; 5: vertex chamber; 6: iron yoke; 7: solenoid coils; 8: compensation coils; 9: mini-β-quadrupole.

EXP 5
RUN 1085
EVT 16582
TRIG 0
PROJ RZ

SCAL 0.068

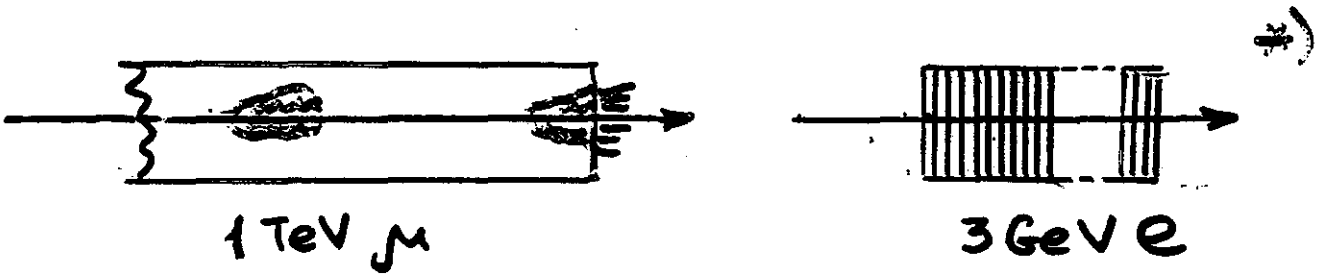
ARGUS



LIMITED AVAILABILITY OF HIGH ENERGY MUON BEAMS

↓

USE A FEW GeV ELECTRON BEAM AS A SOURCE OF ELECTRON-PHOTON CASCADES. DUE TO THERMALIZATION PROCESSES SLOW SHOWER PARTICLES DO NOT REMEMBER THEIR PARENTS (e OR γ) AND GRANDPARENTS (μ).

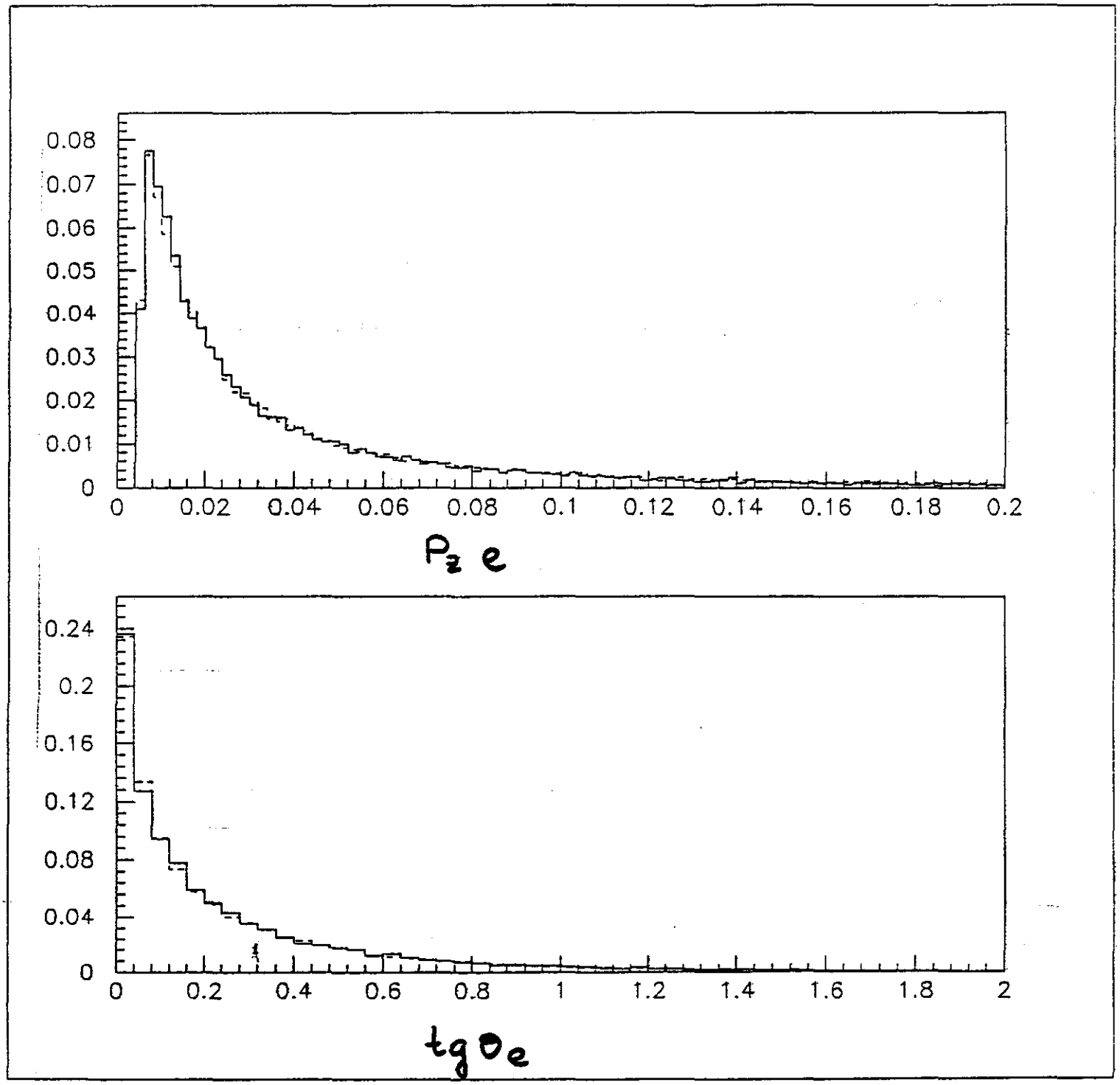


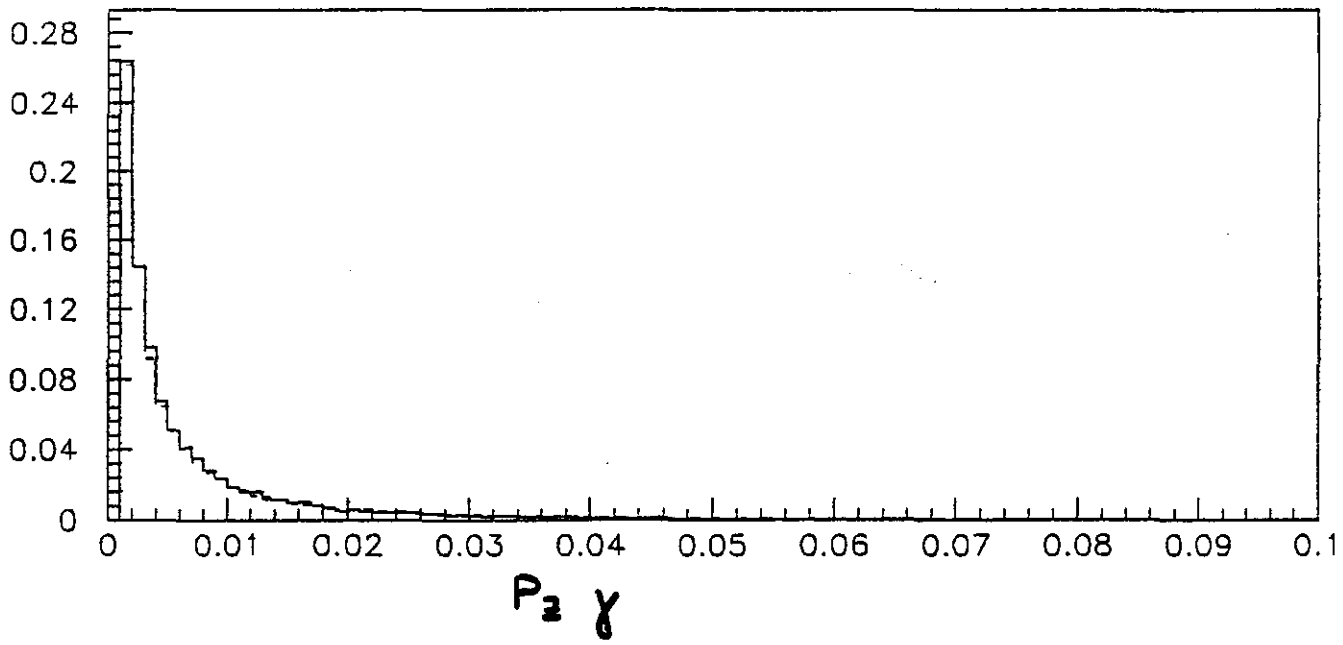
SHOWERS INITIATED BY 1 TeV μ AND 3 GeV e ARE IDENTICAL IN MANY RESPECTS

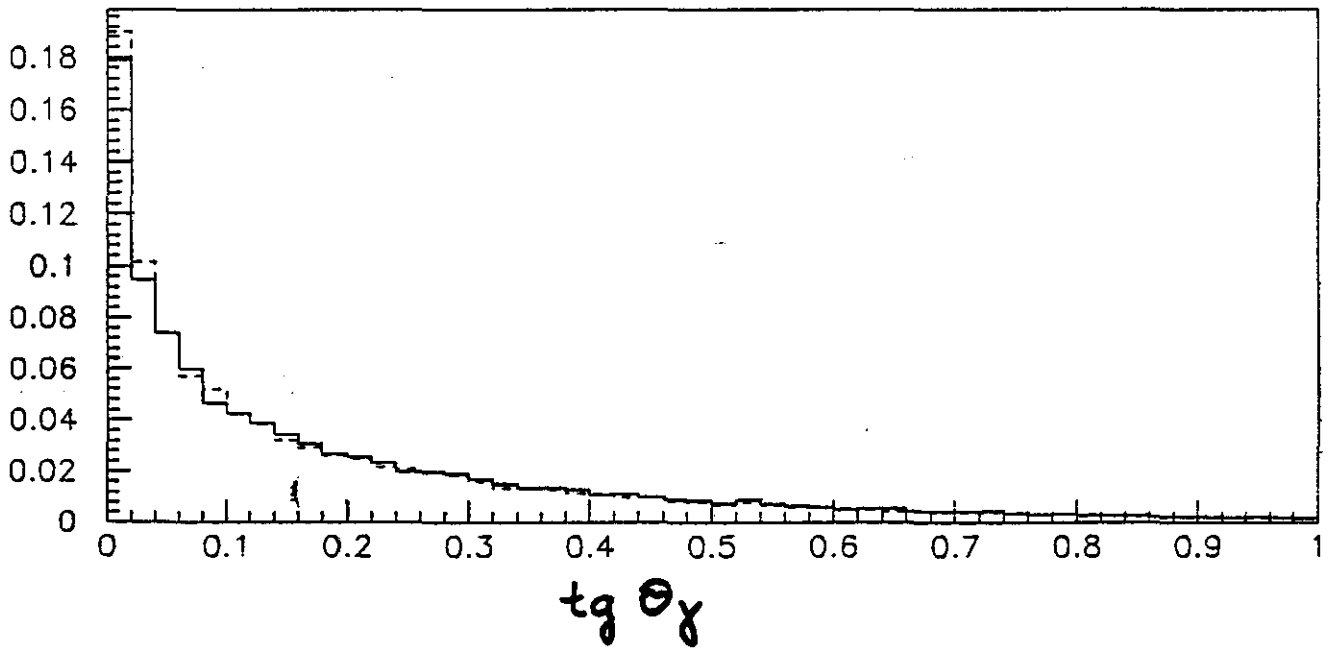
*) IN THE FOLLOWING CONTRIBUTIONS OF DIFFERENT THICKNESSES FOR 3 GeV ELECTRON ARE TAKEN WITH EQUAL WEIGHTS

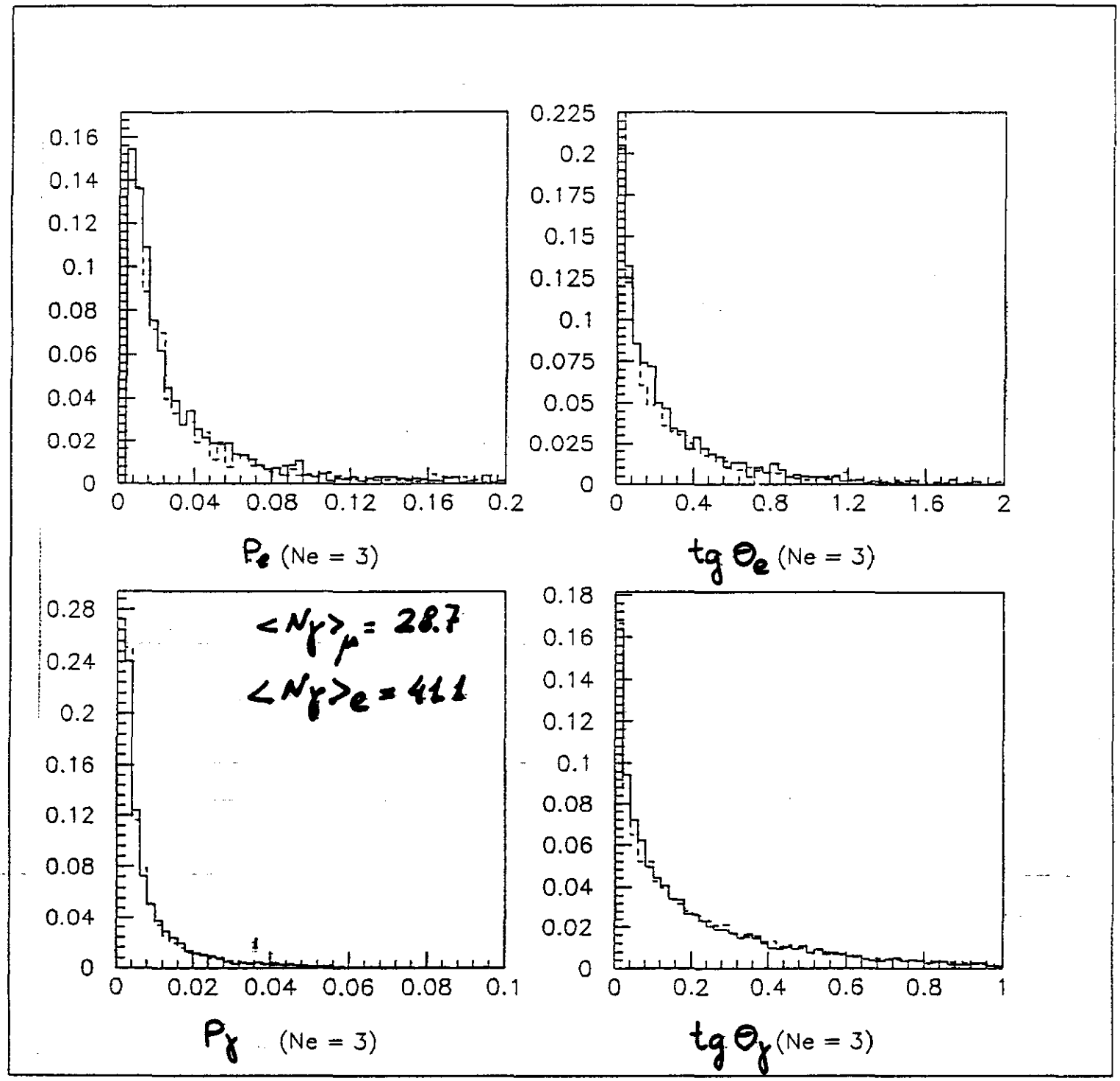
——— μ induced showers

- - - - - - - e induced showers



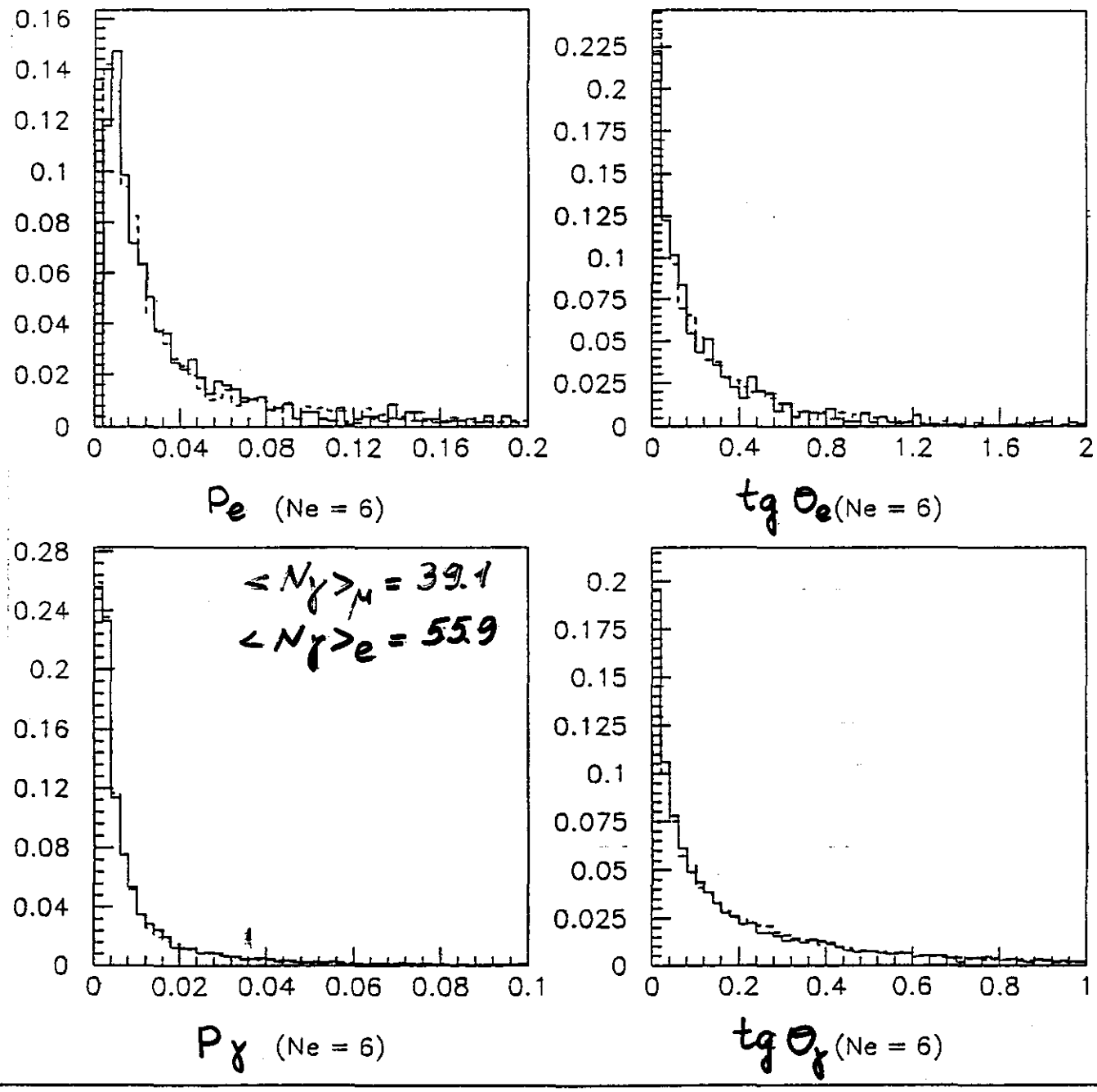

0.28
0.24
0.2
0.16
0.12
0.08
0.04
0
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
0.1
$P_z\ \gamma$


0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
$tg\ \theta_\gamma$



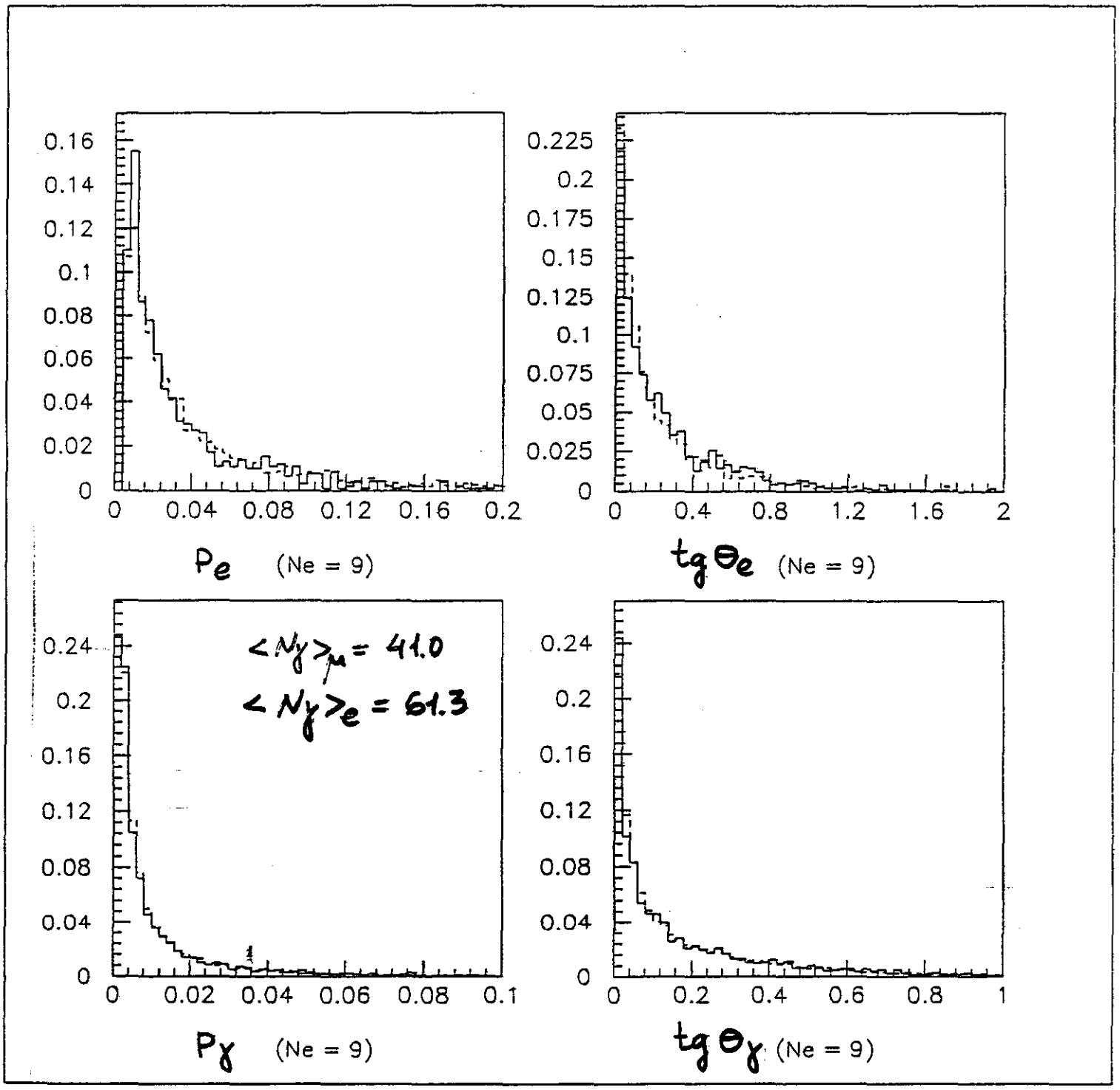
$\langle P_\gamma \rangle_\mu = 8.6$ MeV

$\langle P_\gamma \rangle_e = 8.1$ MeV



$\langle P_\gamma \rangle_\mu = 9.4$ MeV

$\langle P_\gamma \rangle_e = 9.3$ MeV

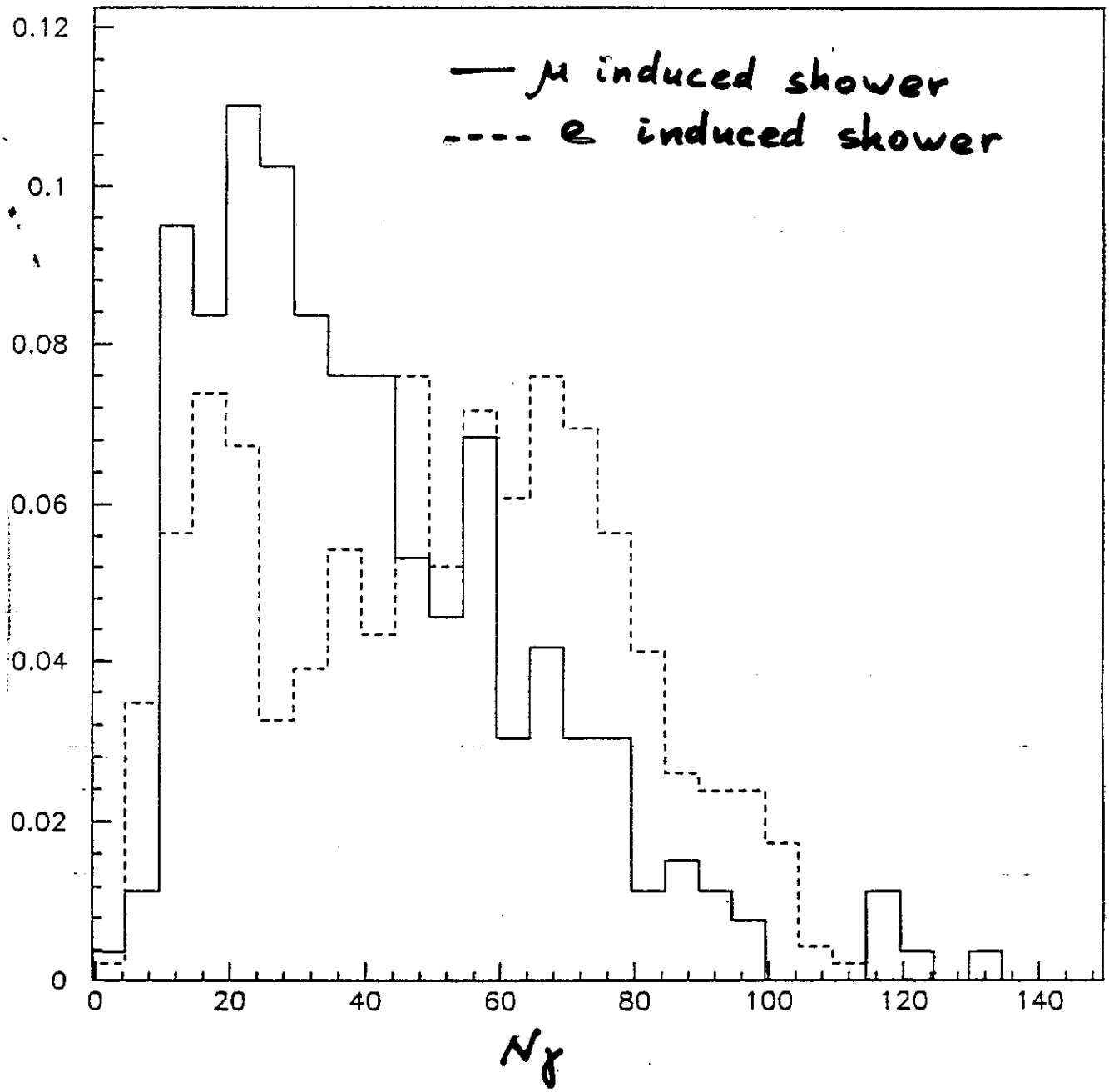


$\langle P_\gamma \rangle_\mu = 10.3$ MeV

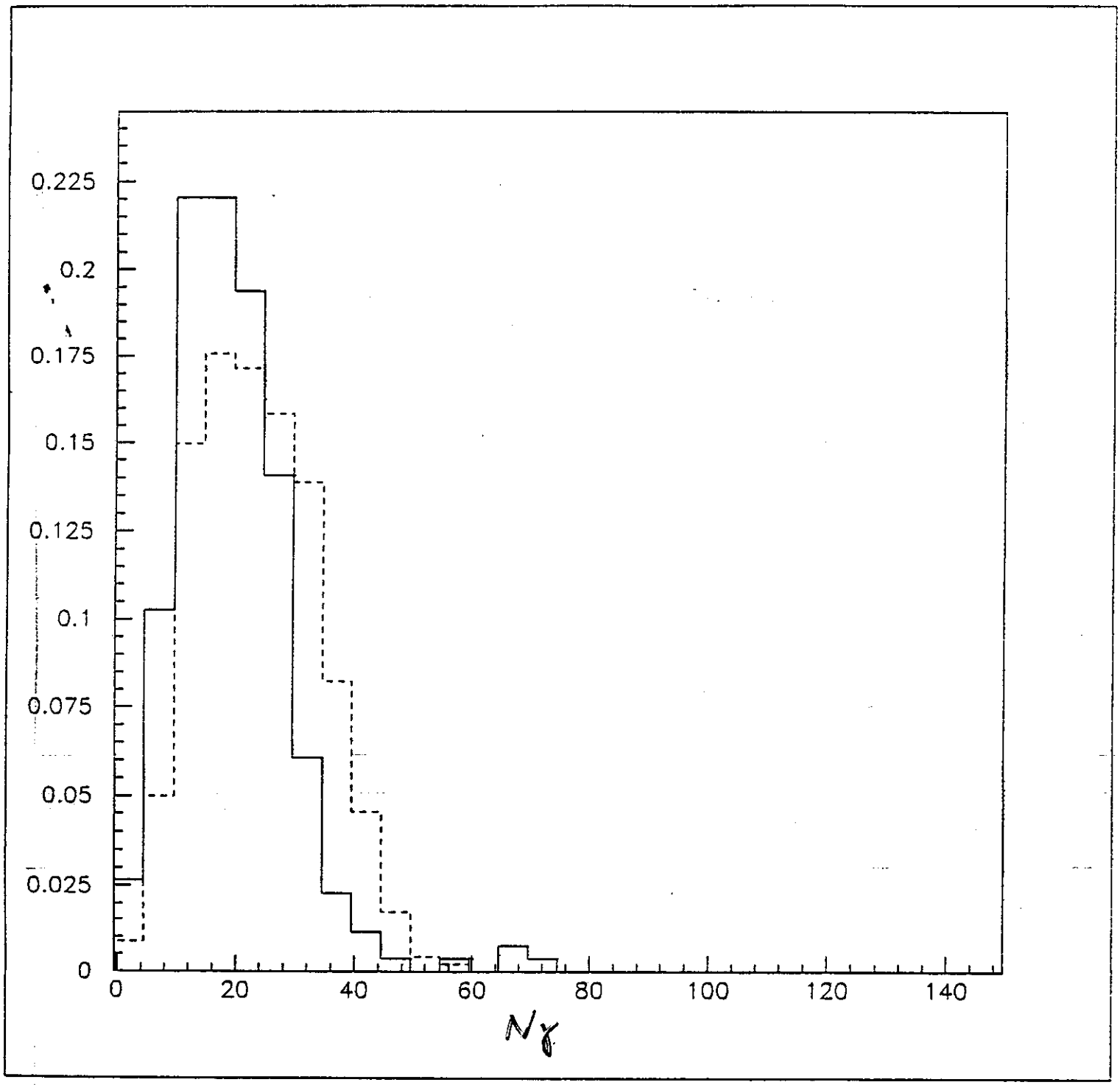
$\langle P_\gamma \rangle_e = 10.1$ MeV

COMPARISON OF γ- MULTIPLICITY

$N_e = 5$ or 6



COMPARISON OF γ MULTIPLICITY ($n_e = 5,6$) FOR PHOTONS CLOSE TO THE MUON TRACK: $tg\,\theta_{\gamma,\mu} \leq 0.1$

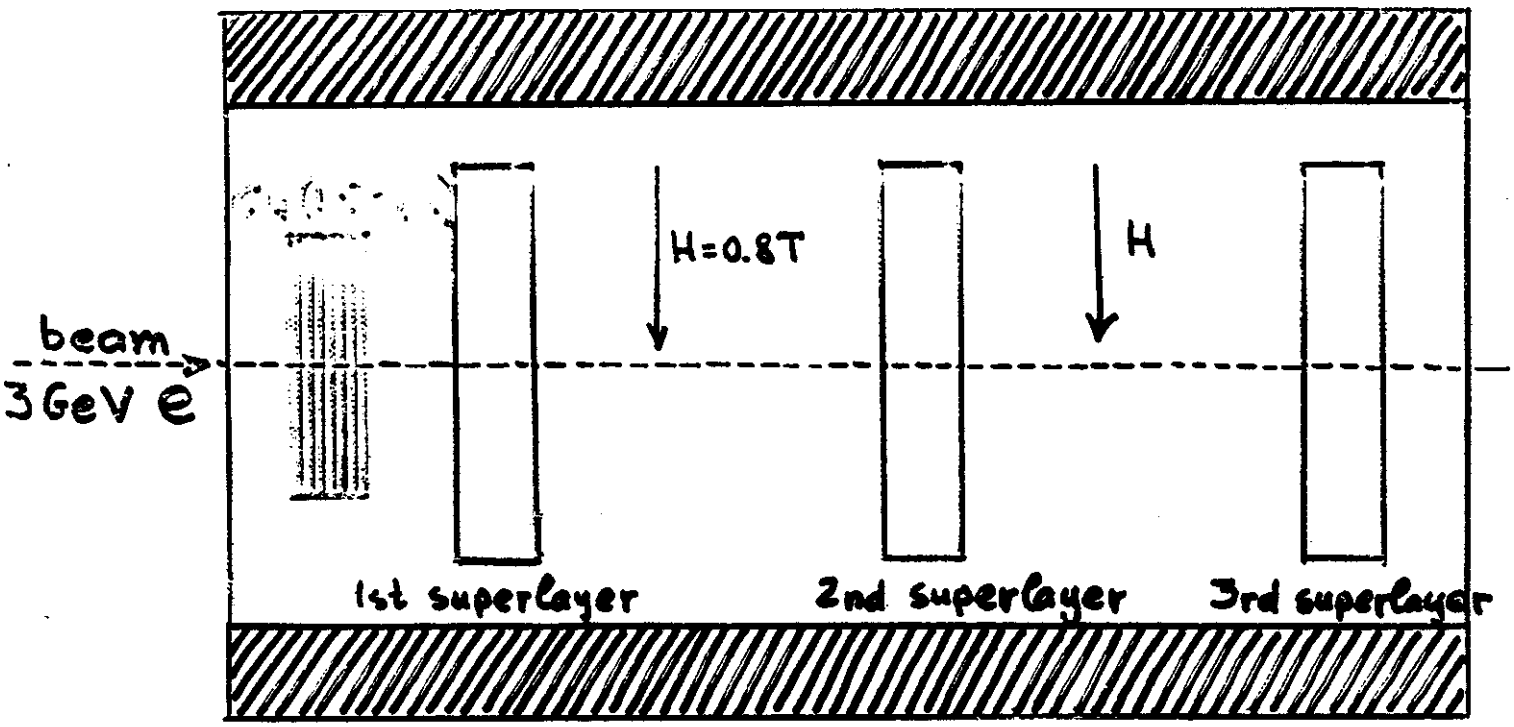


$N_e = 3$: $\langle N_\gamma \rangle_\mu = 13.4$ $\langle N_\gamma \rangle_e = 17.7$

$N_e = 6$: $\langle N_\gamma \rangle_\mu = 22.7$ $\langle N_\gamma \rangle_e = 27.6$

$N_e = 9$: $\langle N_\gamma \rangle_\mu = 34.3$ $\langle N_\gamma \rangle_e = 34.7$

WE PROPOSE TO STUDY PATTERN RECOGNITION AND MOMENTUM MEASUREMENT CAPABILITIES OF MUON DETECTOR USING ELECTRON BEAM AT ITEP



- EXISTING CONVENTIONAL MAGNET CAN PROVIDE UNIFORM MAGNETIC FIELD UP TO 1.2T
  MAGNET WORKING SPACE: 630 × 600 × 1900 mm

- CALORIMETER MOCK-UP CONSISTS OF 1-30 1cm THICK PLATES

- MUON SUPELAYER PROTOTYPES CAN BE BASED ON DIFFERENT TECHNOLOGIES:
  PDT, LSDT, CSC

GOALS OF R&D PROPOSAL:

1. STUDY OF THE PERFORMANCE OF MUON DETECTOR PROTOTYPES BASED ON DIFFERENT TECHNOLOGIES

- OPTIMIZATION OF NUMBER OF LAYERS IN SUPERLAYER
- INFLUENCE OF MAGNETIC FIELD AND AIR GAP BETWEEN CALORIMETER EDGE AND 1ST SUPERLAYER
- INFLUENCE OF THE AMOUNT OF MATERIAL IN SUPERMODULES
- INFLUENCE OF LOW Z ABSORBER IN FRONT OF THE 1ST MUON SUPERMODULE

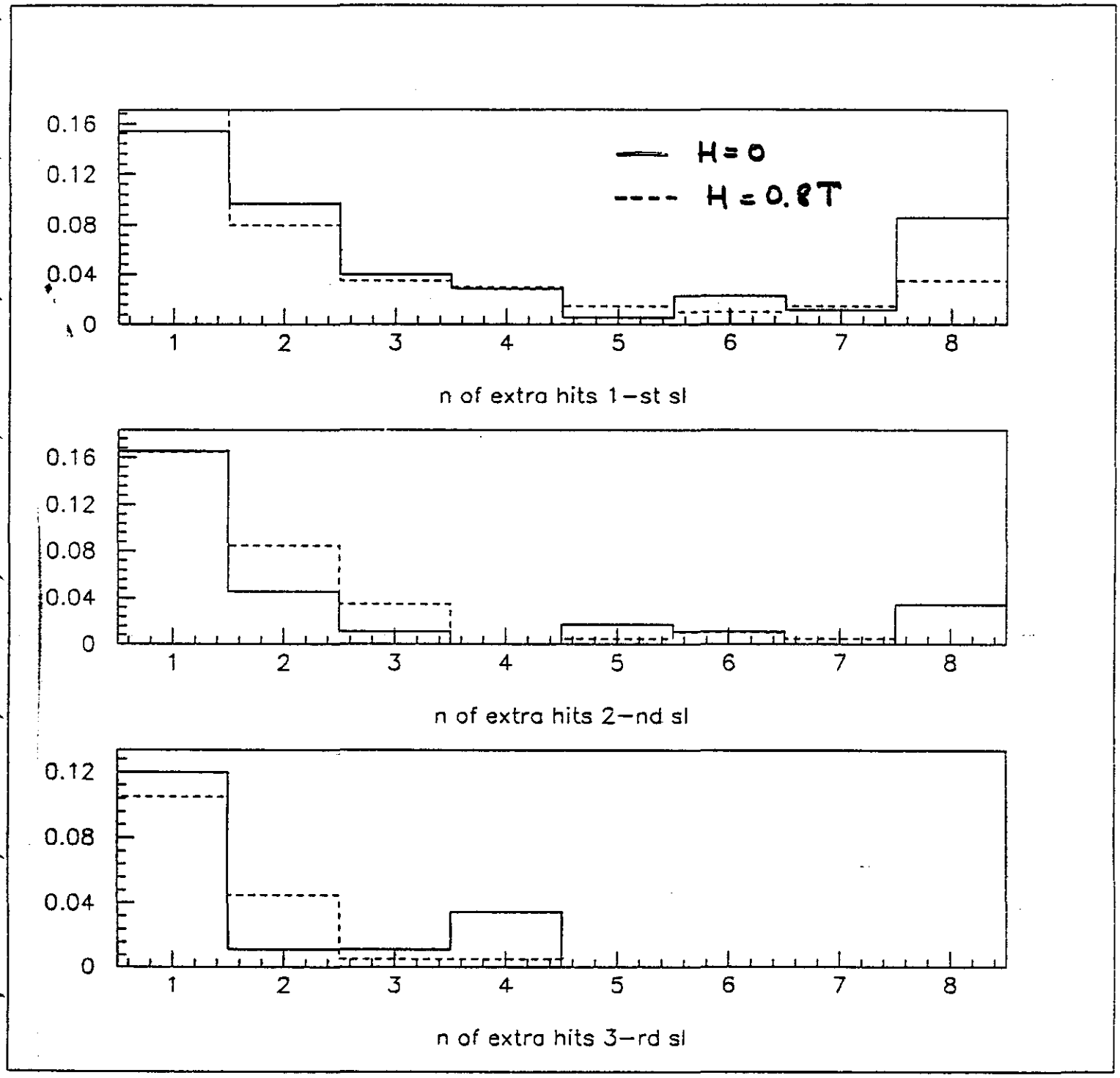
2. PATTERN RECOGNITION

- SIMULATION OF CELL RESPONSE AND READ-OUT ELECTRONICS AND TUNING MC PARAMETERS TO THE EXPERIMENTAL DATA
- SEARCH FOR THE OPTIMUM ALGORITHM OF MUON TRACK RECONSTRUCTION
- CALCULATION OF MUON DETECTION EFFICIENCY AND SPATIAL RESOLUTION

3. TEST OF PWC MUON TRIGGER PERFORMANCE

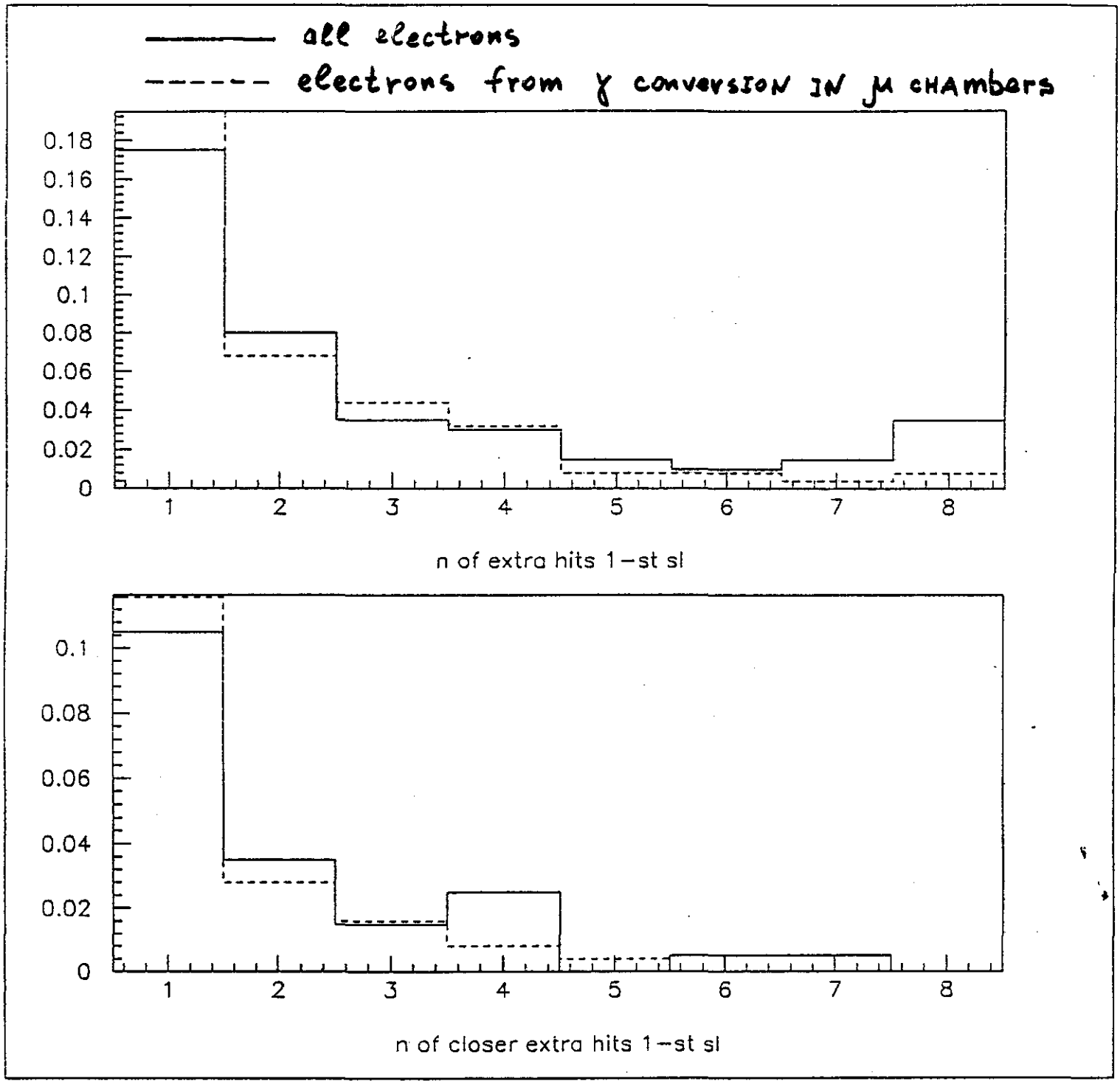
INFLUENCE OF THE MAGNETIC FIELD

NUMBER OF EXTRA HITS IN DIFFERENT SUPERLAYERS

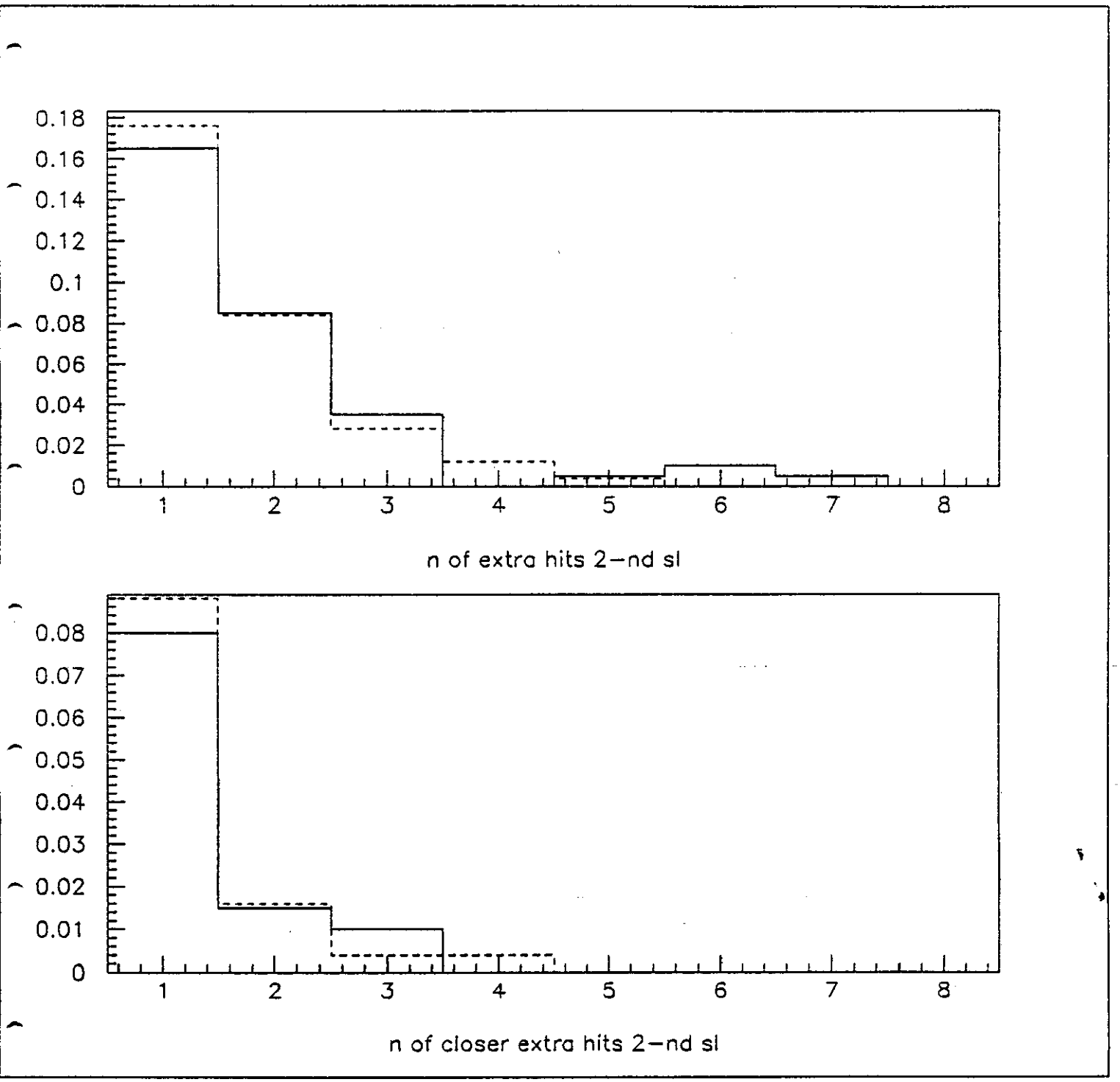


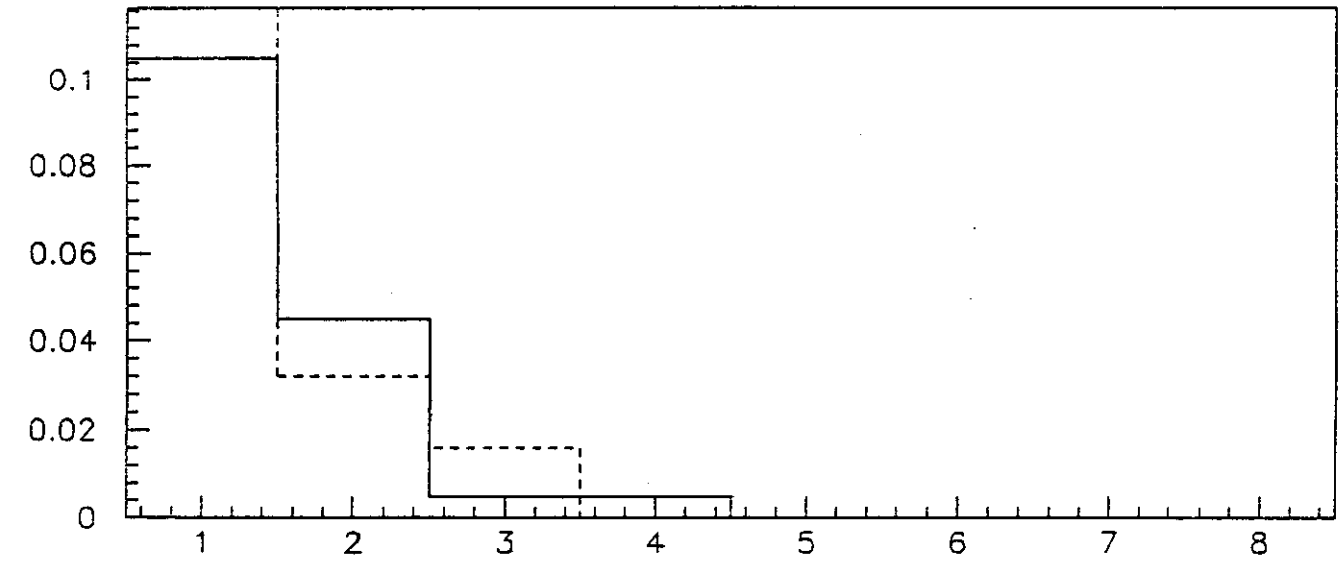
NUMBER OF EXTRA HITS IN DIFFERENT SUPERLAYERS

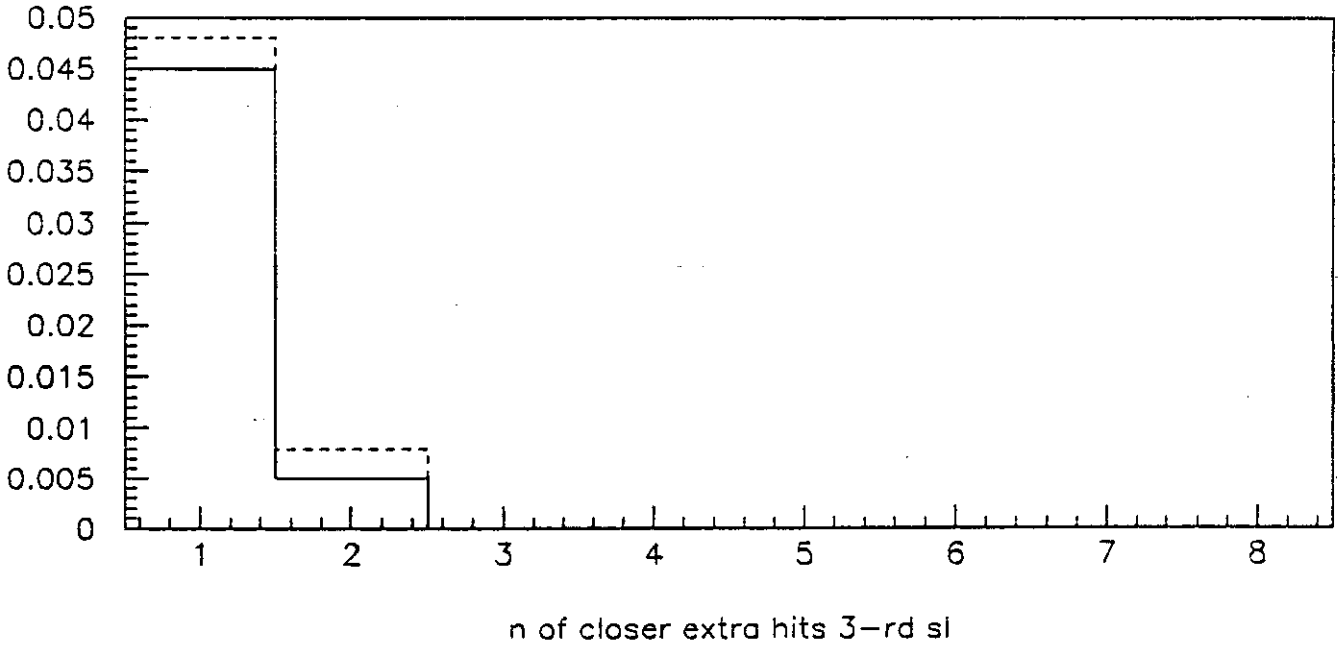
in the same tube with muon



INFLUENCE OF THE AMOUNT OF MATERIAL IN MUON SYSTEM


0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
1
2
3
4
5
6
7
8
n of extra hits 2−nd sl
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
1
2
3
4
5
6
7
8
n of closer extra hits 2−nd sl


0.1
0.08
0.06
0.04
0.02
0
1
2
3
4
5
6
7
8
n of extra hits 3−rd sl


0.05
0.045
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
1
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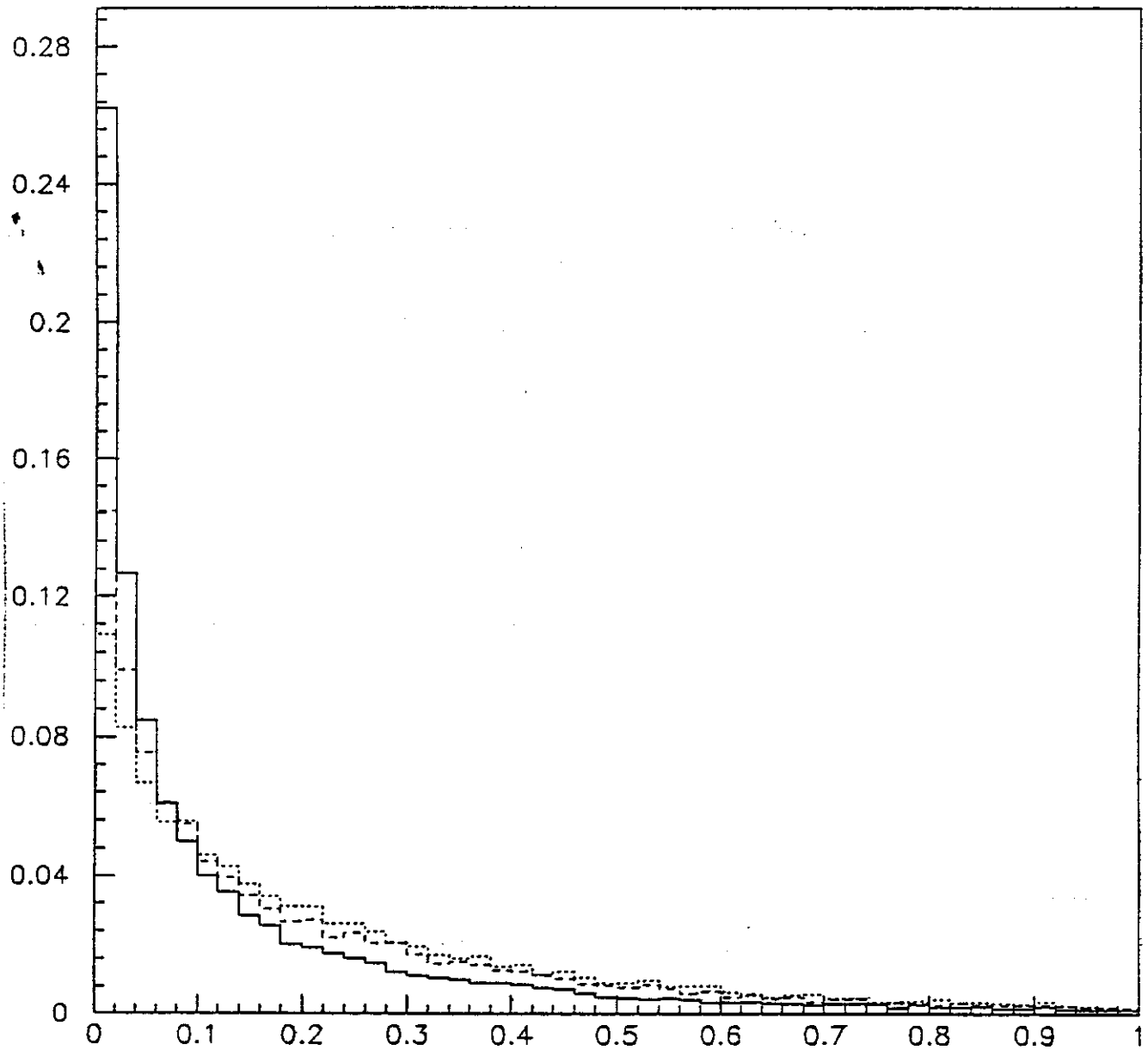
4
5
6
7
8
n of closer extra hits 3−rd sl


0.28
0.24
0.2
0.16
0.12
0.08
0.04
0
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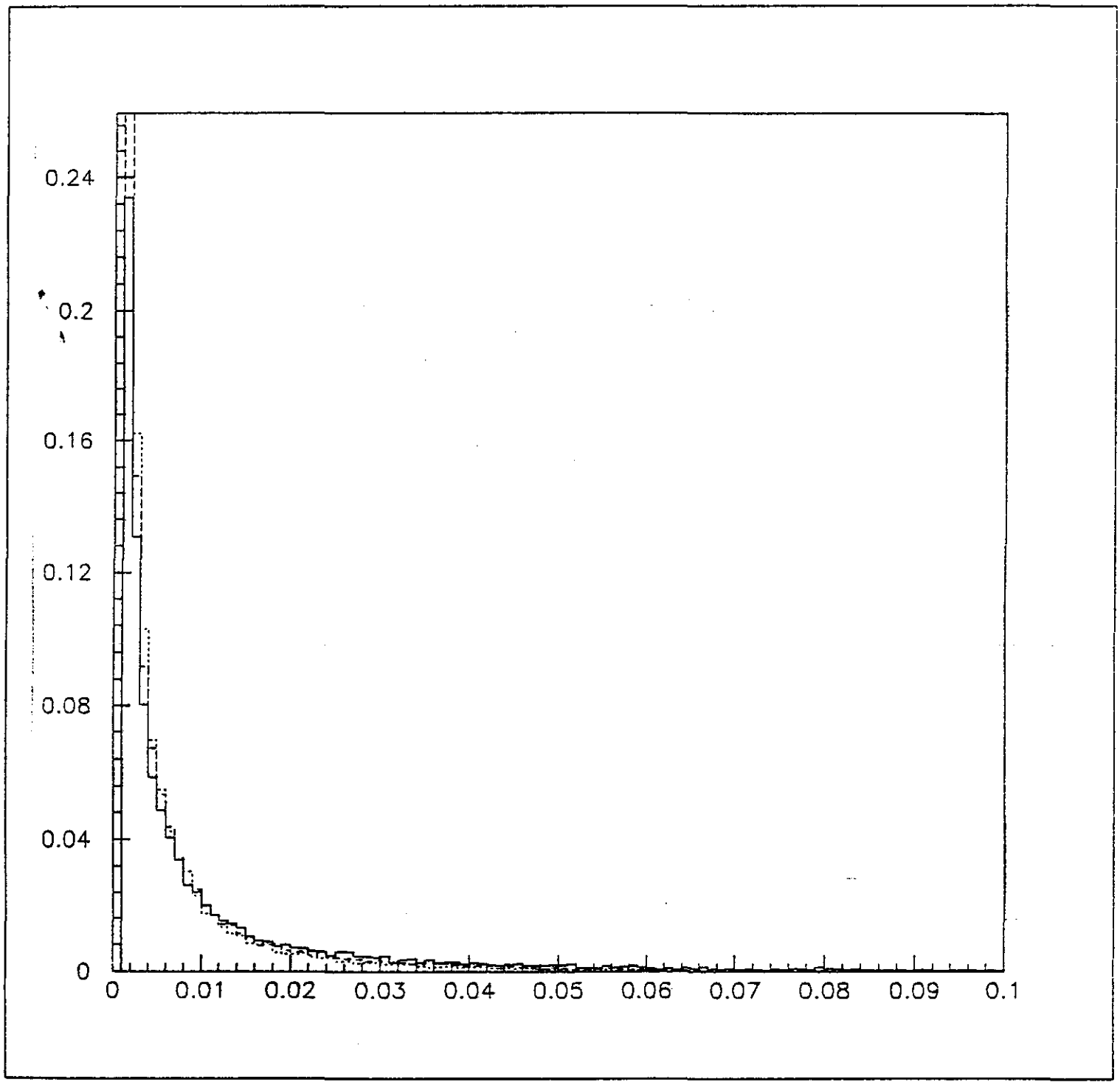
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1


0.24
0.2
0.16
0.12
0.08
0.04
0
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
0.1

MONTE CARLO STUDIES

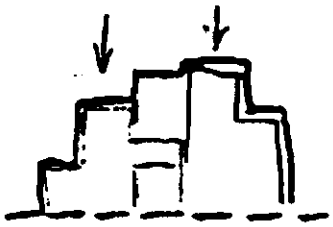
Chiaki Yanagisawa

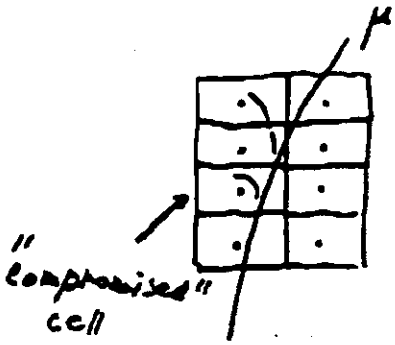
July 3, 1992
at SSCL

Pattern Recognition Problem
with
Endcap Muon System
Barrel

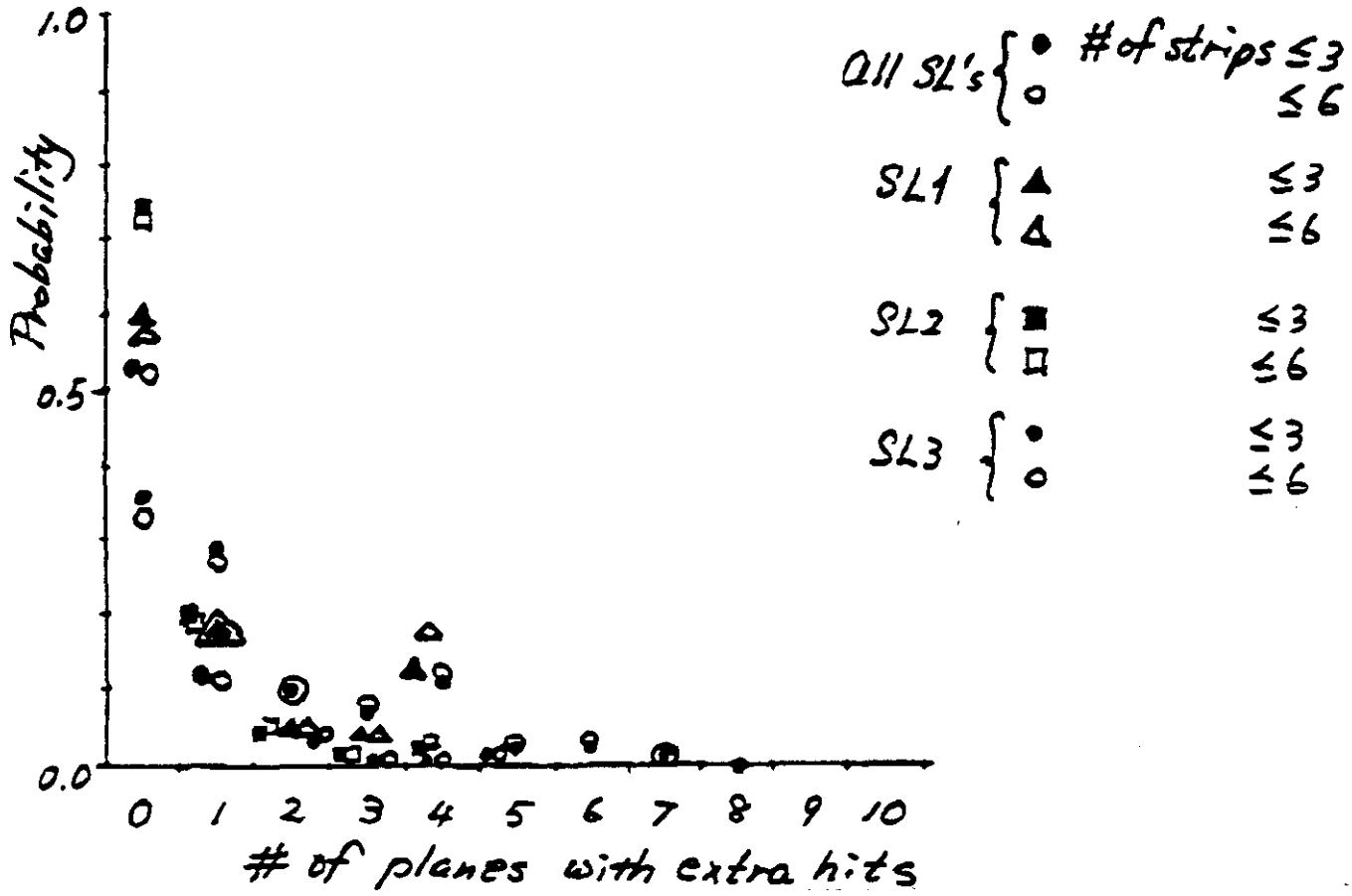
Chiaki Yanagisawa

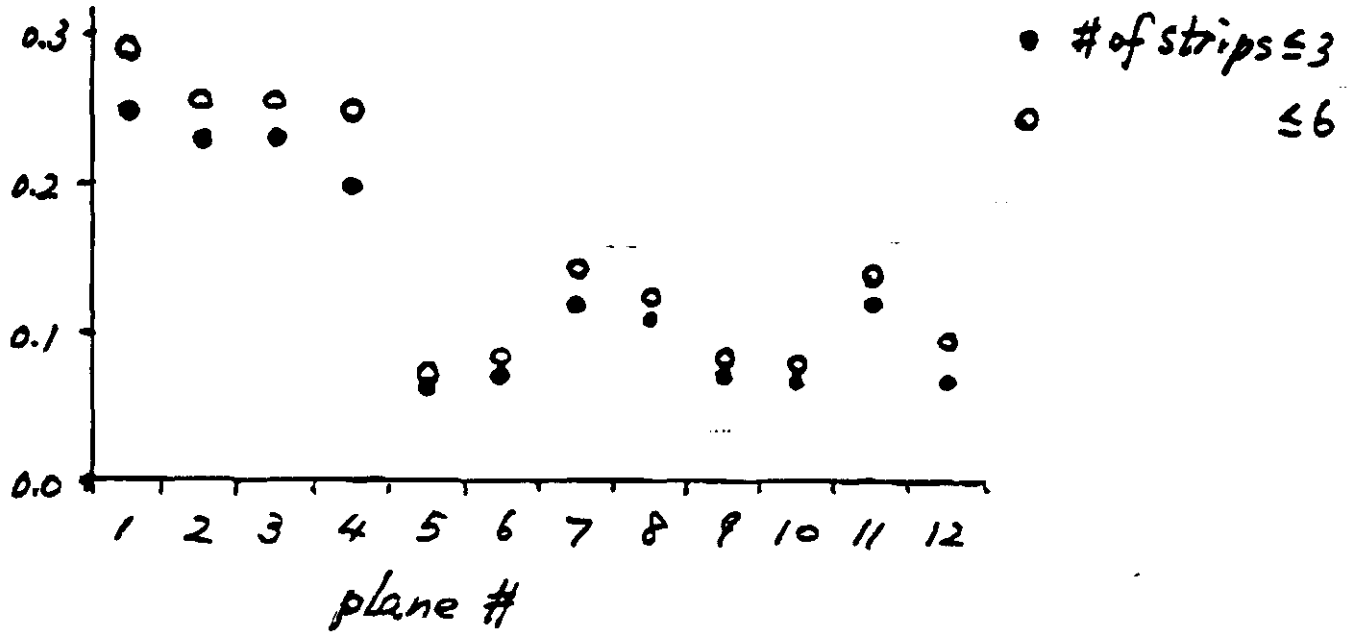
- MC data:
  (1) 1 TeV/c single muons
  (2) $t\bar{t}$, $m_t = 250\ \mathrm{GeV}/c^2$, $50\ \mathrm{GeV}/c \le p_T^{top}$
- Baseline 1 geometry
- δ-ray threshold 10 keV
- All muons required to reach the last plane





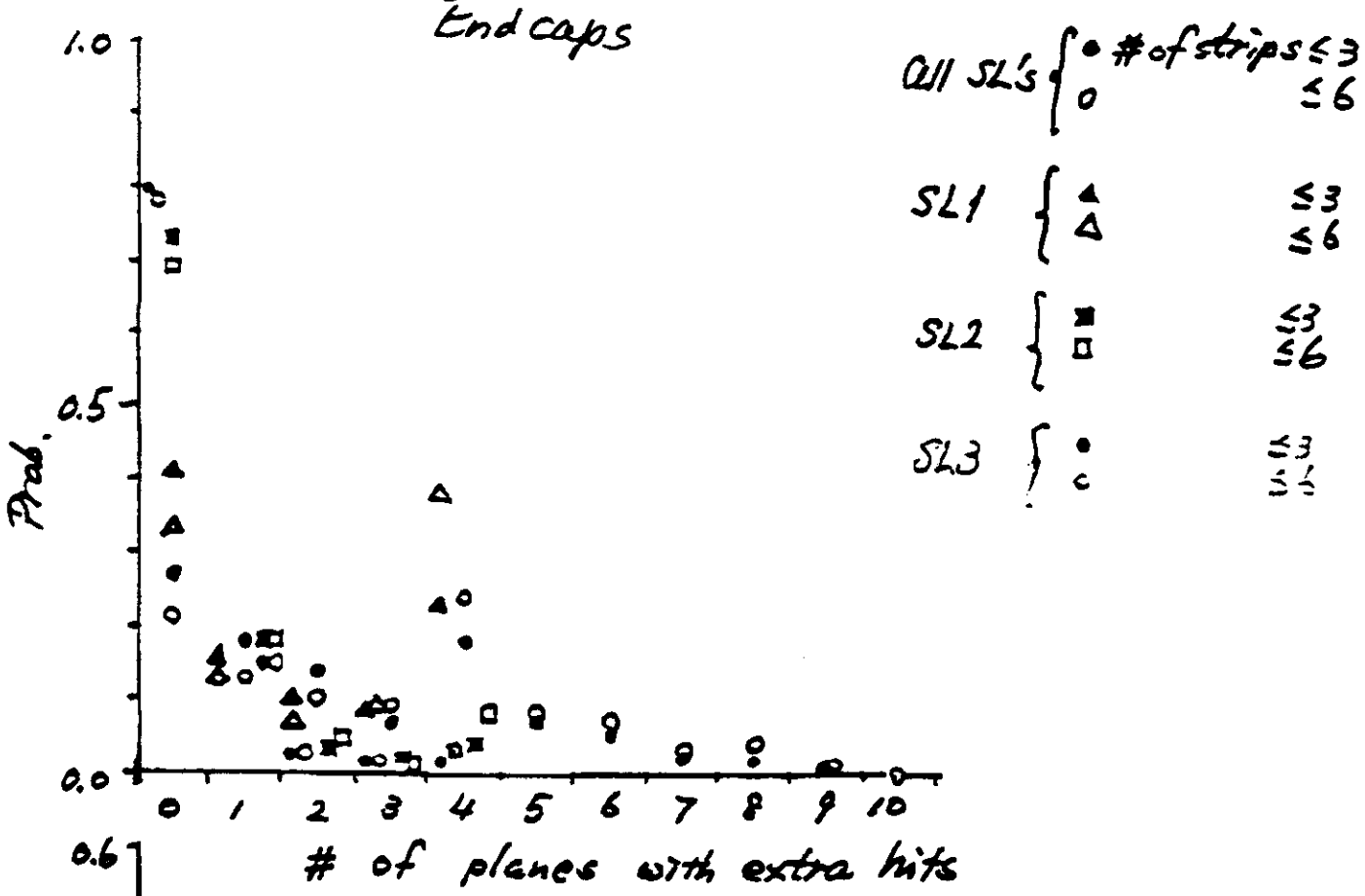
1 TeV/c single μ's in Endcaps

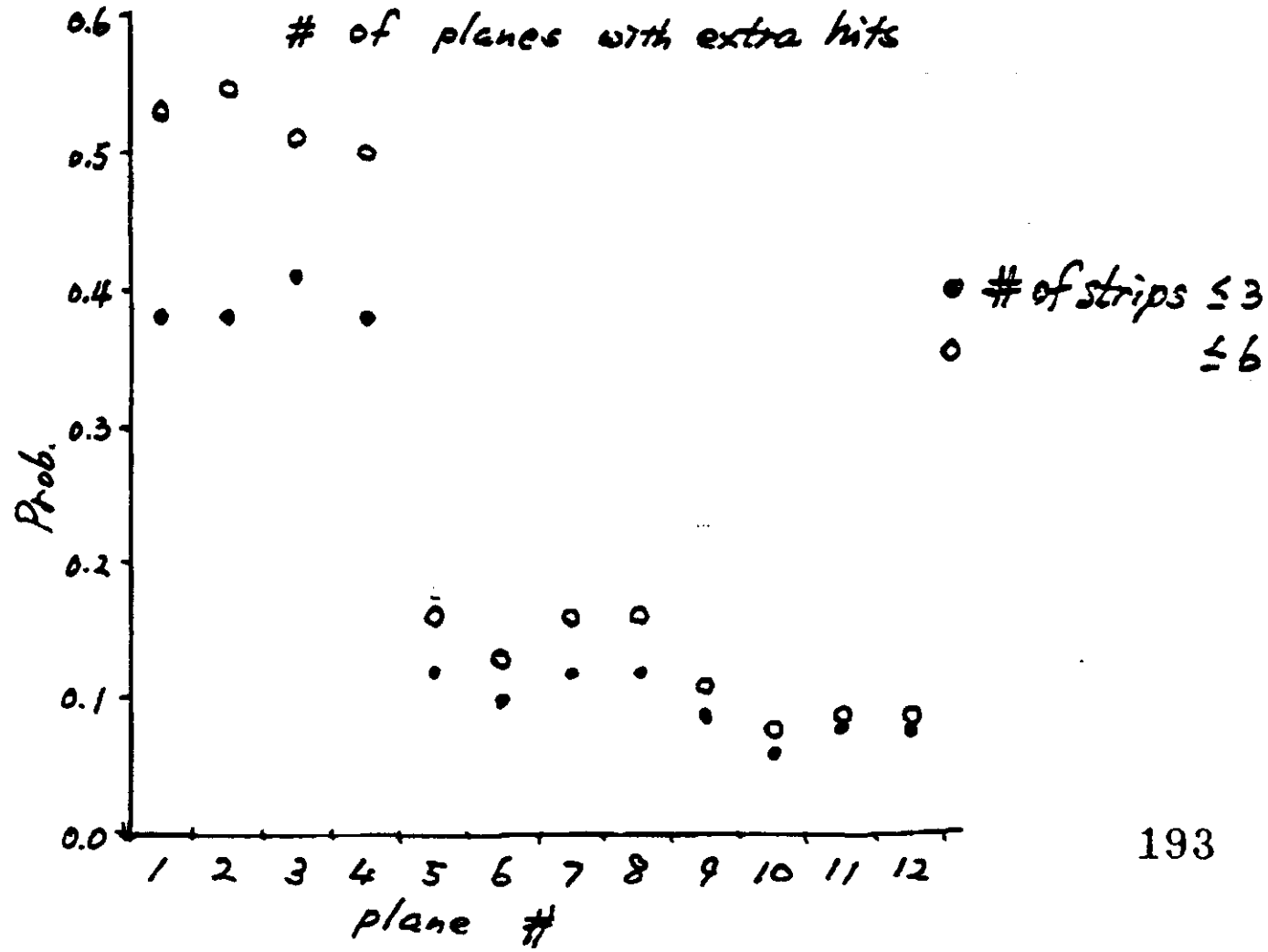




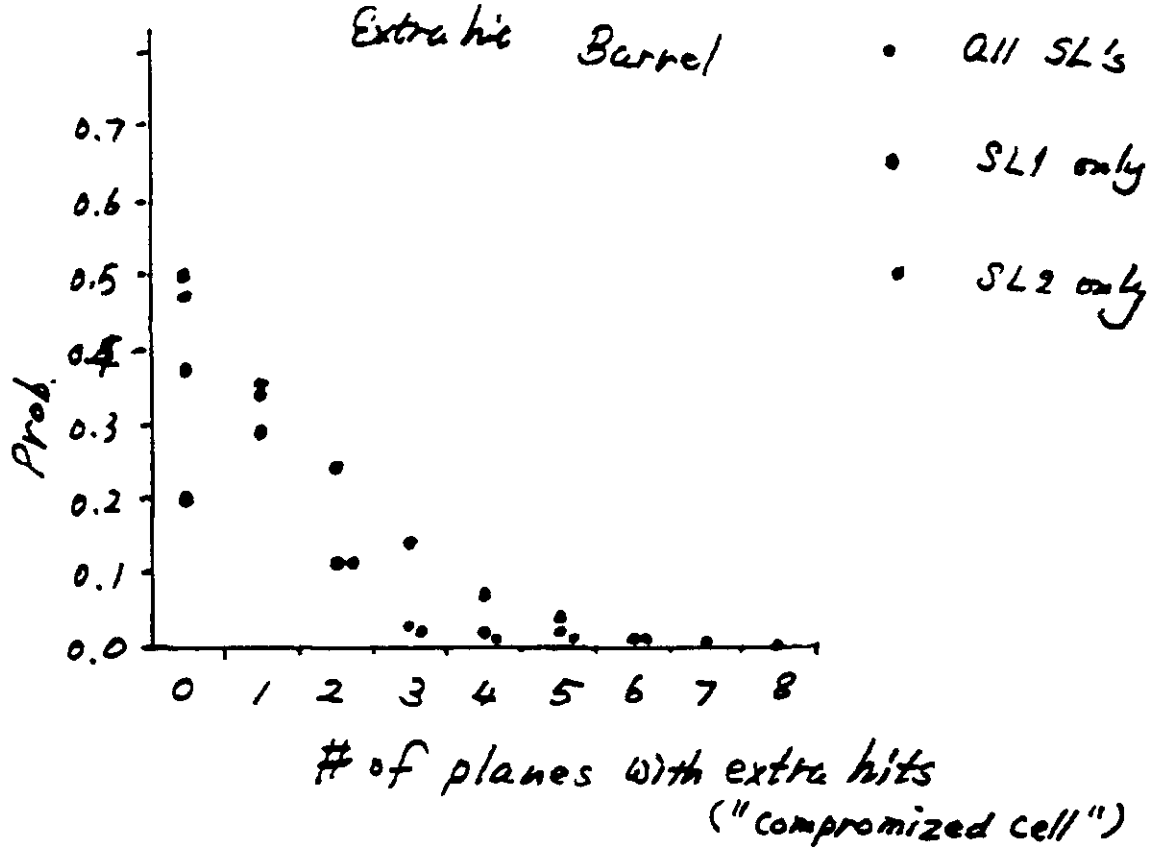
$t\bar{t}$ $p_t > 50$ GeV $m_t = 250$ GeV/c^2

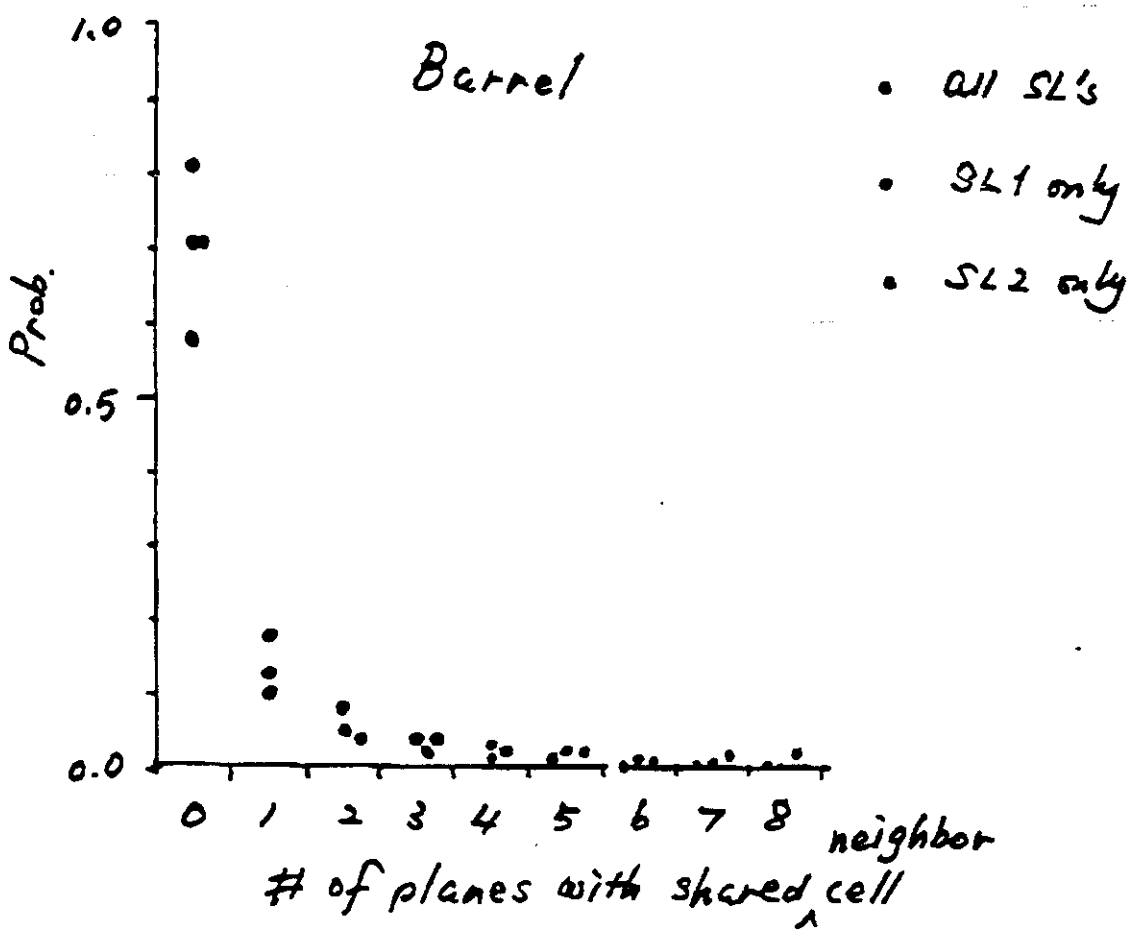
End caps



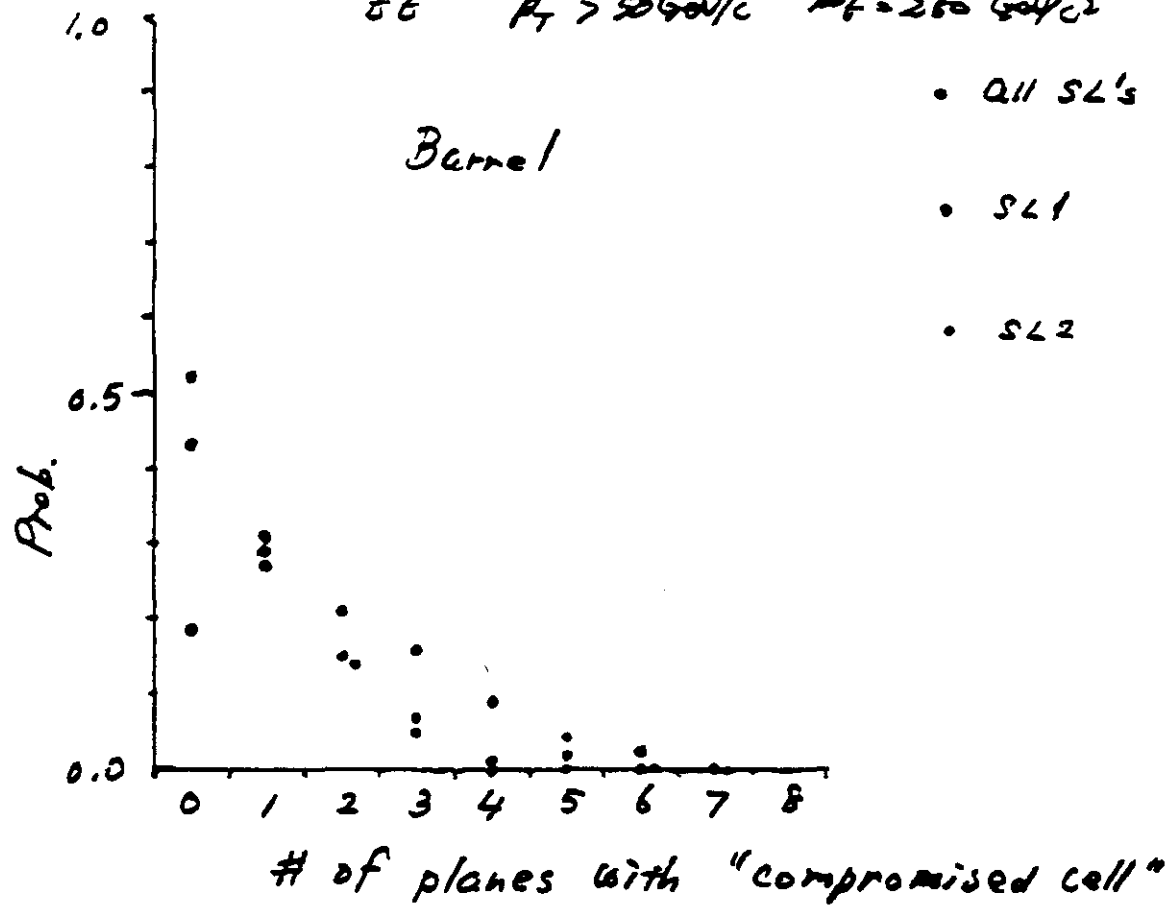


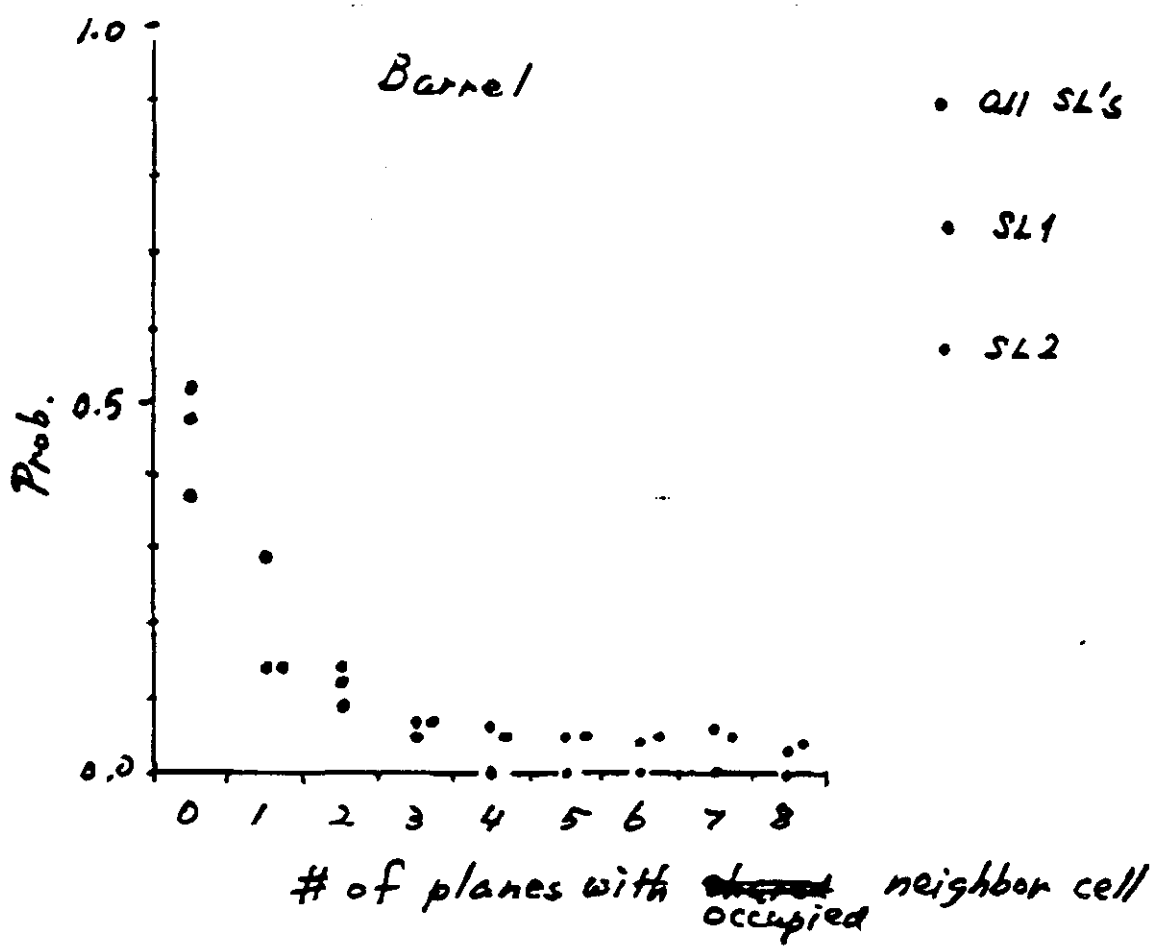
1 TeV/c single muons
cell size 2.5 cm

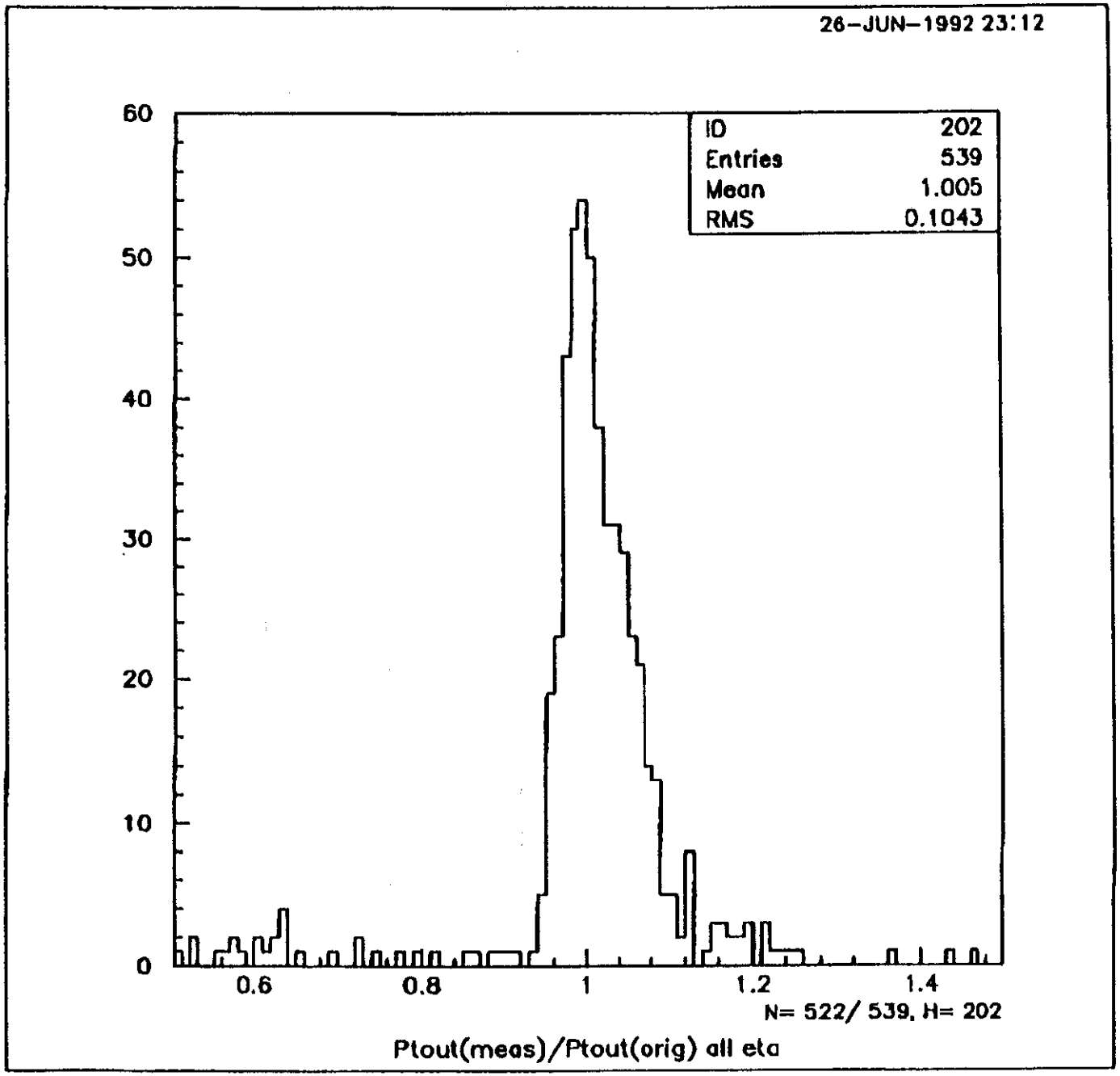


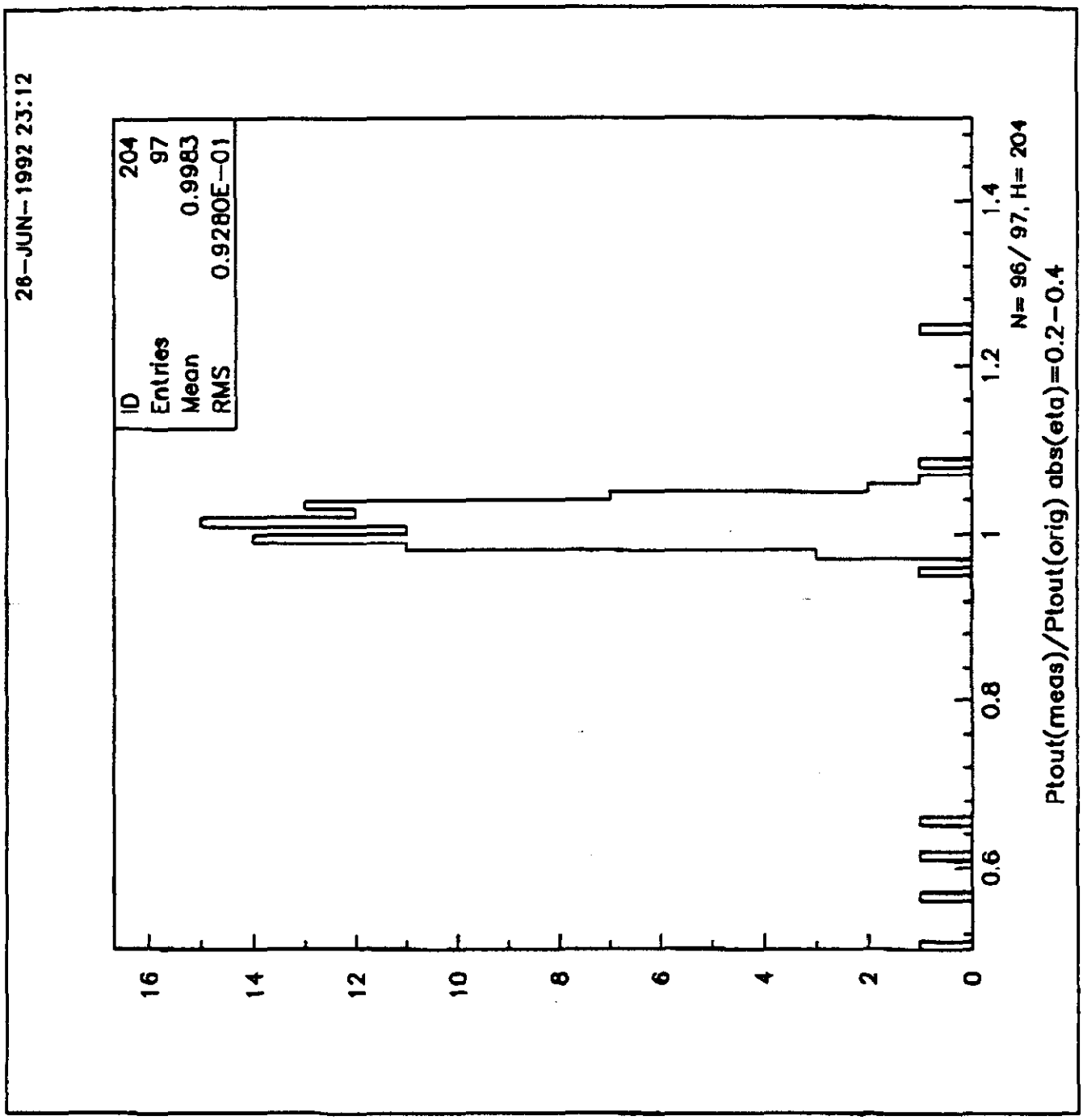


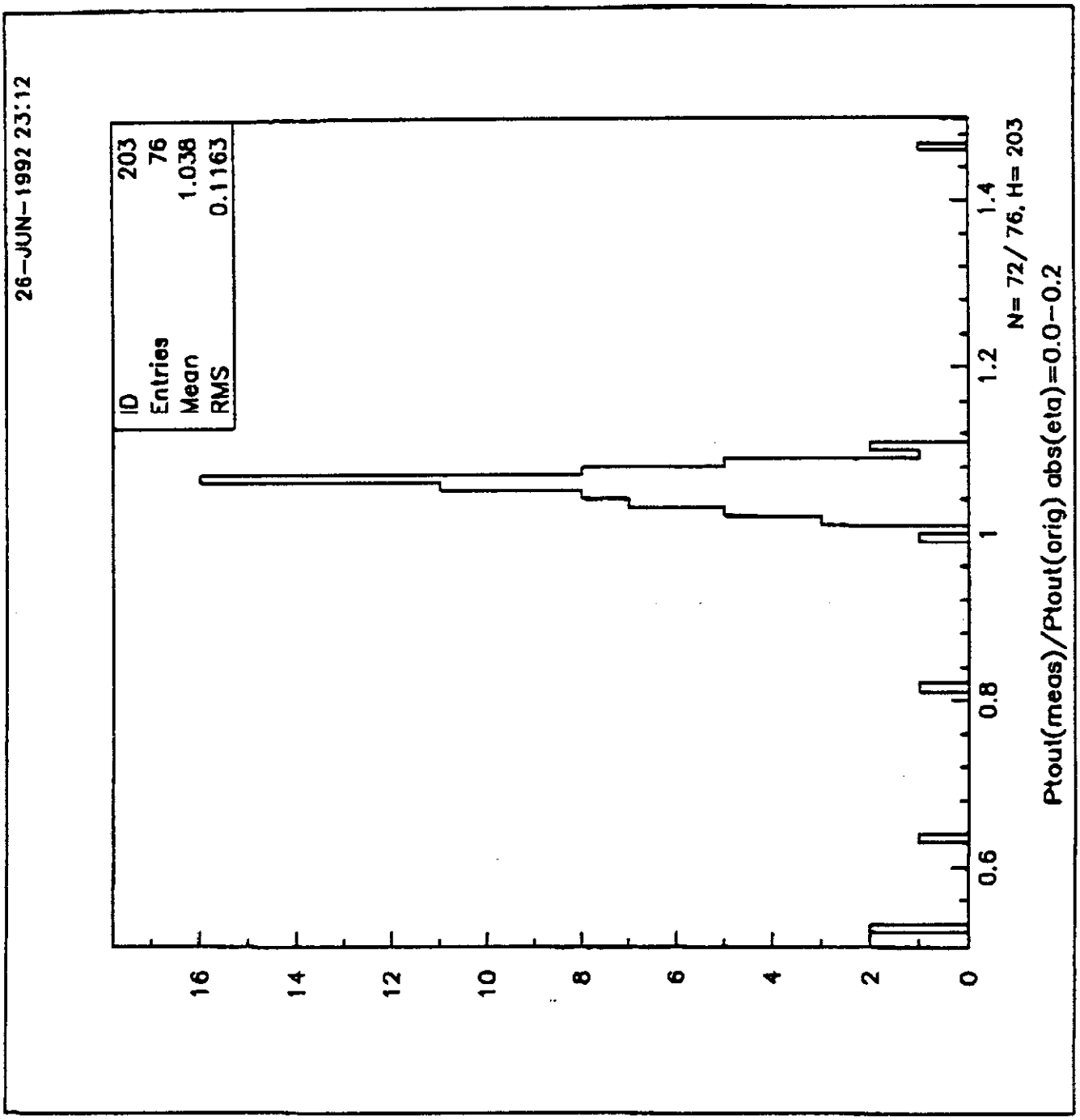
$t\bar{t}$ $p_T > 50$ GeV/c $m_t = 200$ GeV/c²

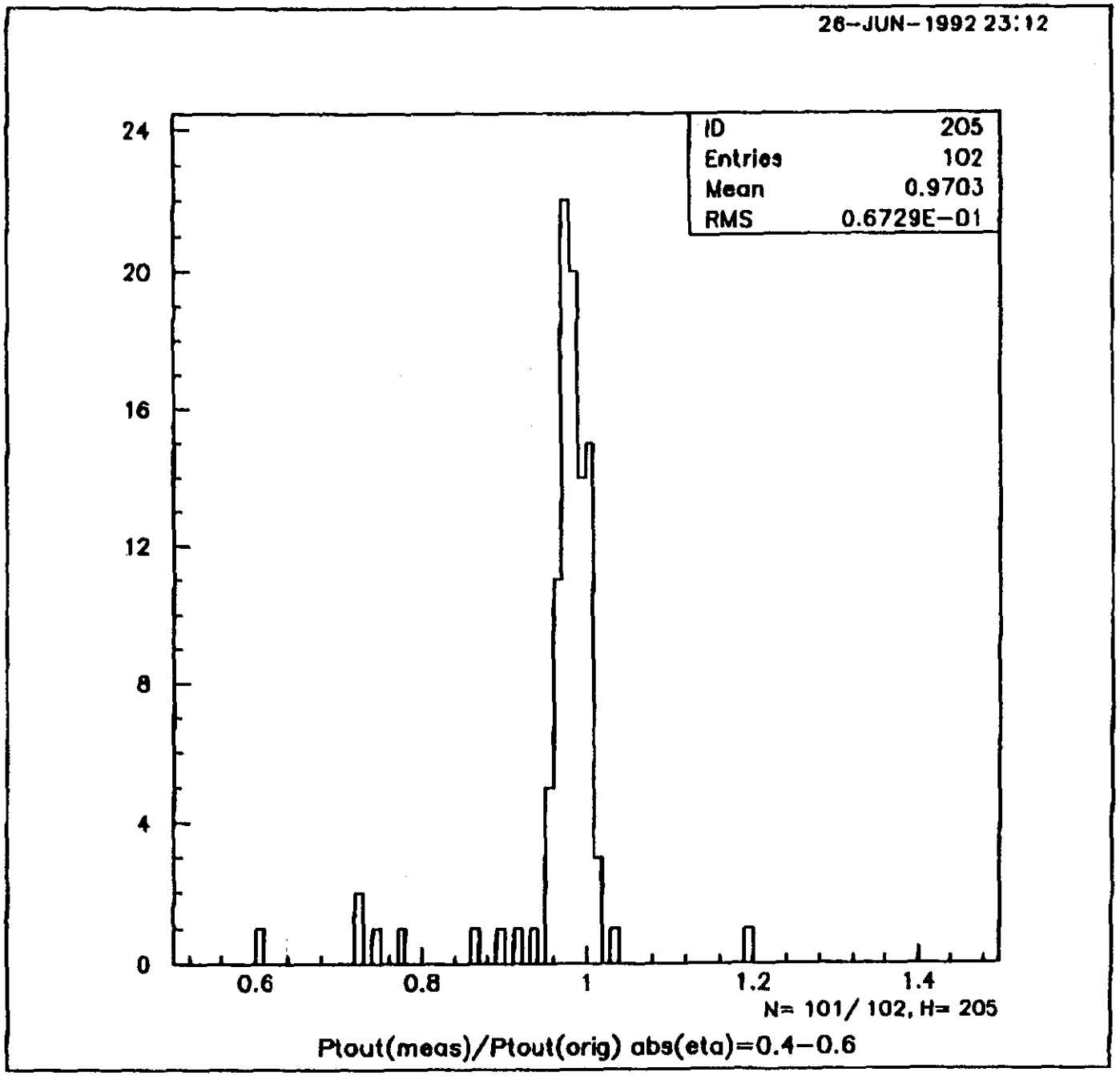


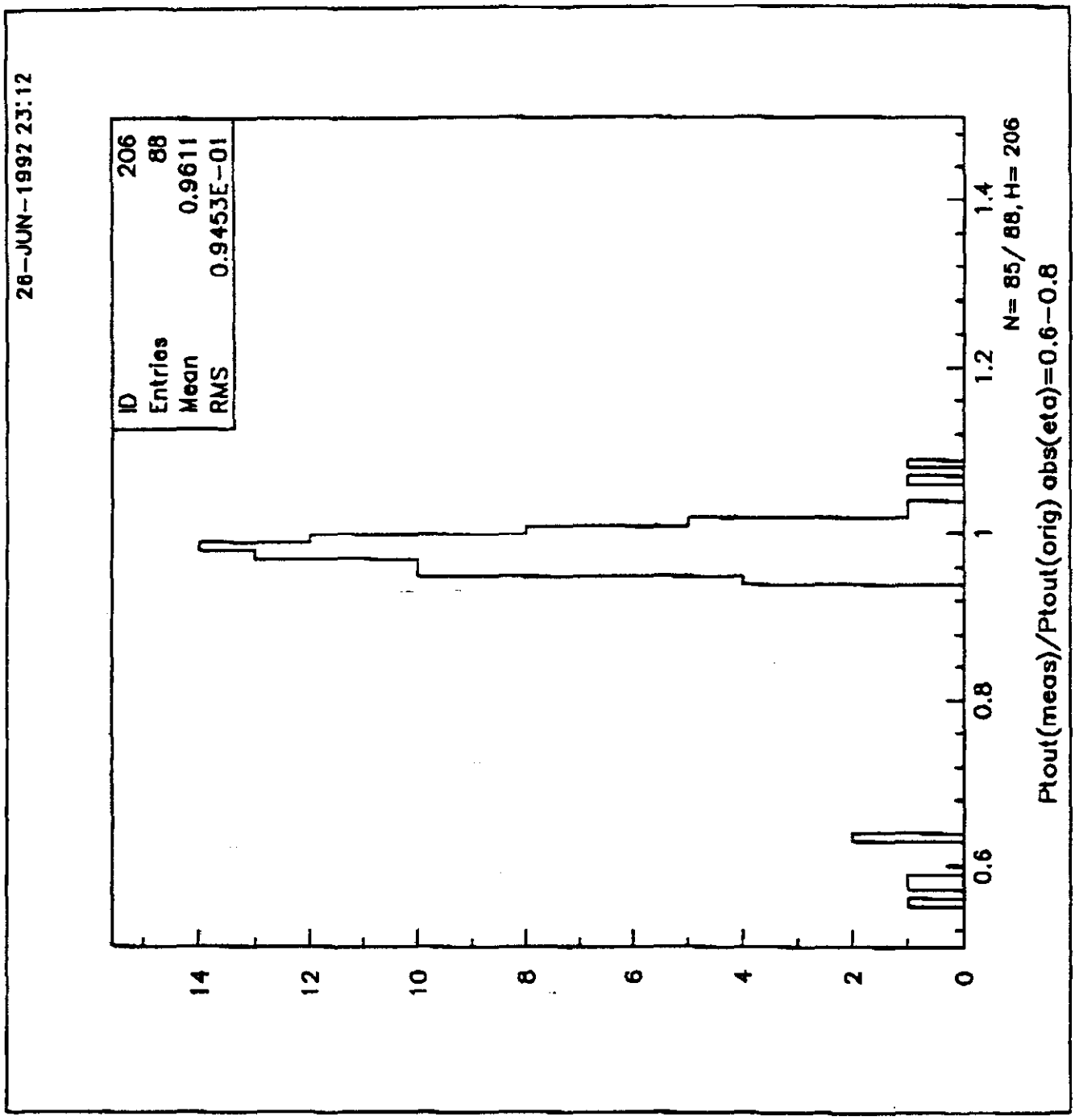


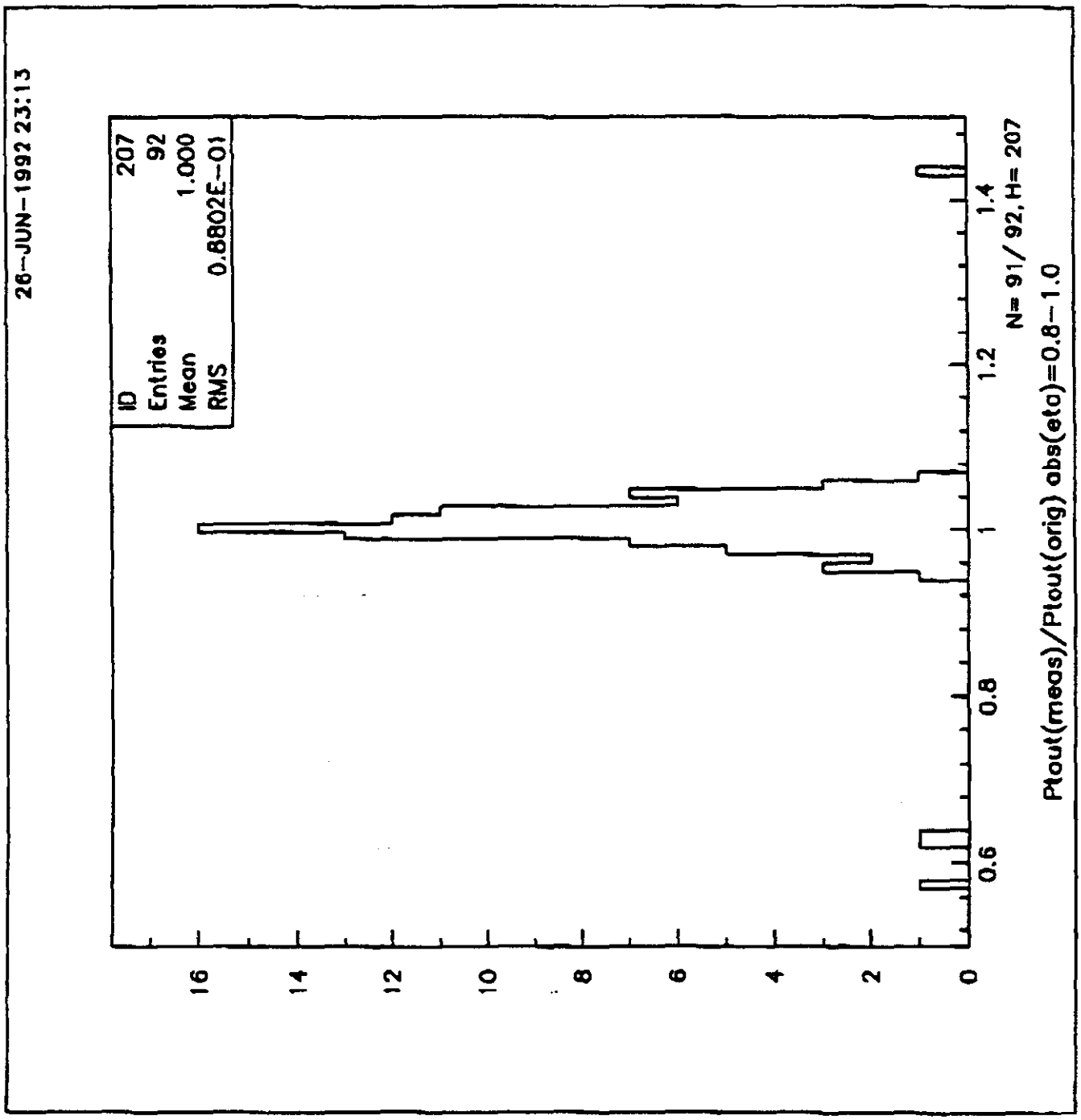

26-JUN-1992 23:12
ID 202
Entries 539
Mean 1.005
RMS 0.1043
60
50
40
30
20
10
0
0.6
0.8
1
1.2
1.4
N= 522/ 539, H= 202
Ptout(meas)/Ptout(orig) all eta

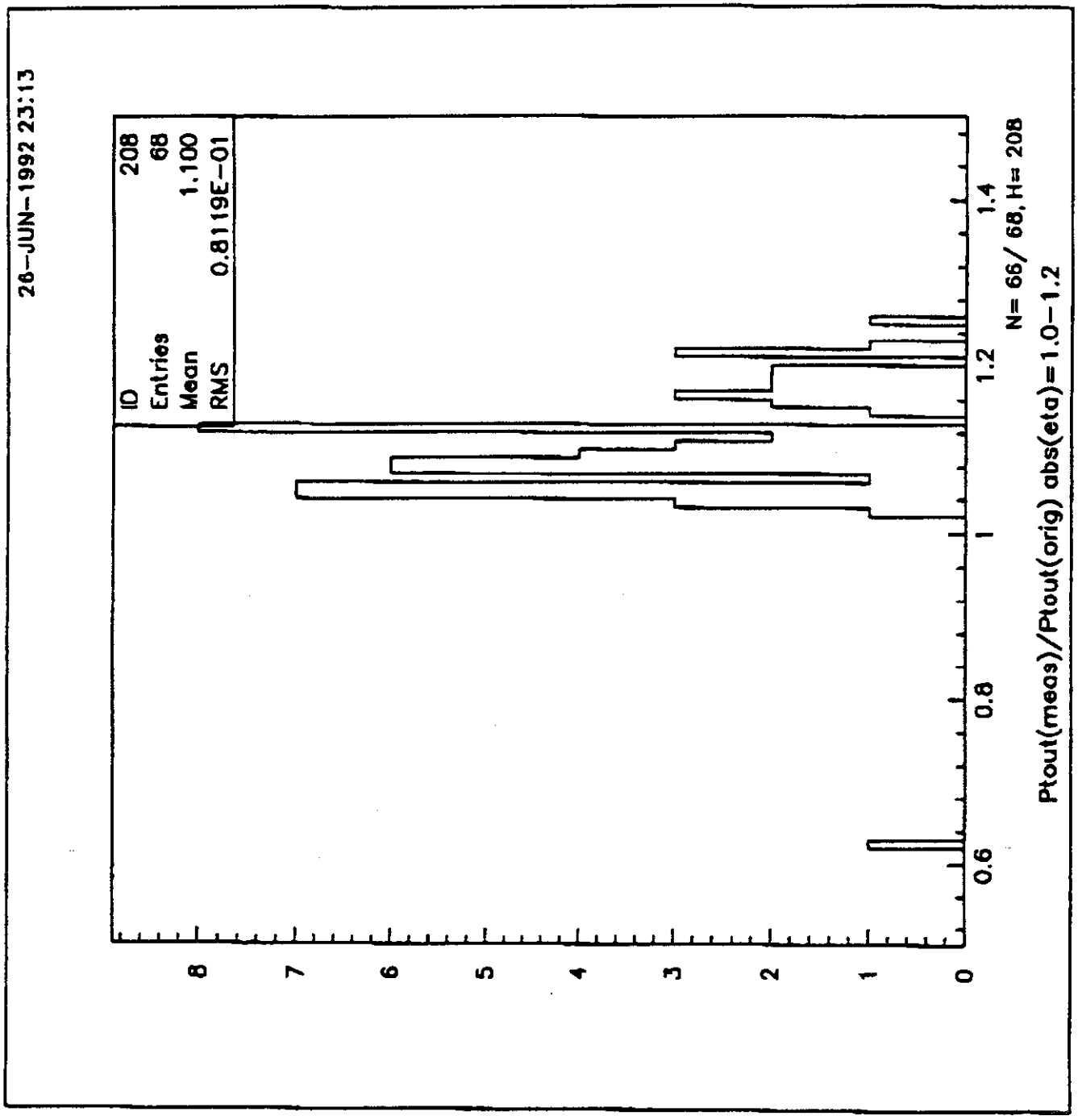

26-JUN-1992 23:12
ID 204
Entries 97
Mean 0.9983
RMS 0.9280E-01
16
14
12
10
8
6
4
2
0
0.6
0.8
1
1.2
1.4
N= 96/ 97, H= 204
Ptout(meas)/Ptout(orig) abs(eta)=0.2-0.4


26-JUN-1992 23:12
ID 203
Entries 76
Mean 1.038
RMS 0.1163
16
14
12
10
8
6
4
2
0
0.6
0.8
1
1.2
1.4
N= 72/ 76, H= 203
Ptout(meas)/Ptout(orig) abs(eta)=0.0-0.2


26-JUN-1992 23:12
ID 205
Entries 102
Mean 0.9703
RMS 0.6729E-01
24
20
16
12
8
4
0
0.6
0.8
1
1.2
1.4
N= 101/ 102, H= 205
Ptout(meas)/Ptout(orig) abs(eta)=0.4-0.6


26-JUN-1992 23:12
ID 206
Entries 88
Mean 0.9611
RMS 0.9453E-01
0
2
4
6
8
10
12
14
0.6
0.8
1
1.2
1.4
N= 85/ 88, H= 206
Ptout(meas)/Ptout(orig) abs(eta)=0.6-0.8

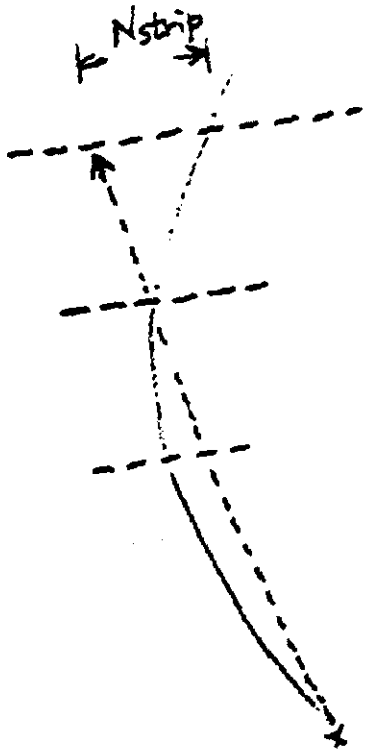

26-JUN-1992 23:13
ID 207
Entries 92
Mean 1.000
RMS 0.8802E-01
16
14
12
10
8
6
4
2
0
0.6
0.8
1
1.2
1.4
N= 91/ 92, H= 207
Ptout(meas)/Ptout(orig) abs(eta)=0.8-1.0


26-JUN-1992 23:13
ID 208
Entries 68
Mean 1.100
RMS 0.8119E-01
0
1
2
3
4
5
6
7
8
0.6
0.8
1
1.2
1.4
N= 66/ 68, H= 208
Ptout(meas)/Ptout(orig) abs(eta)=1.0-1.2

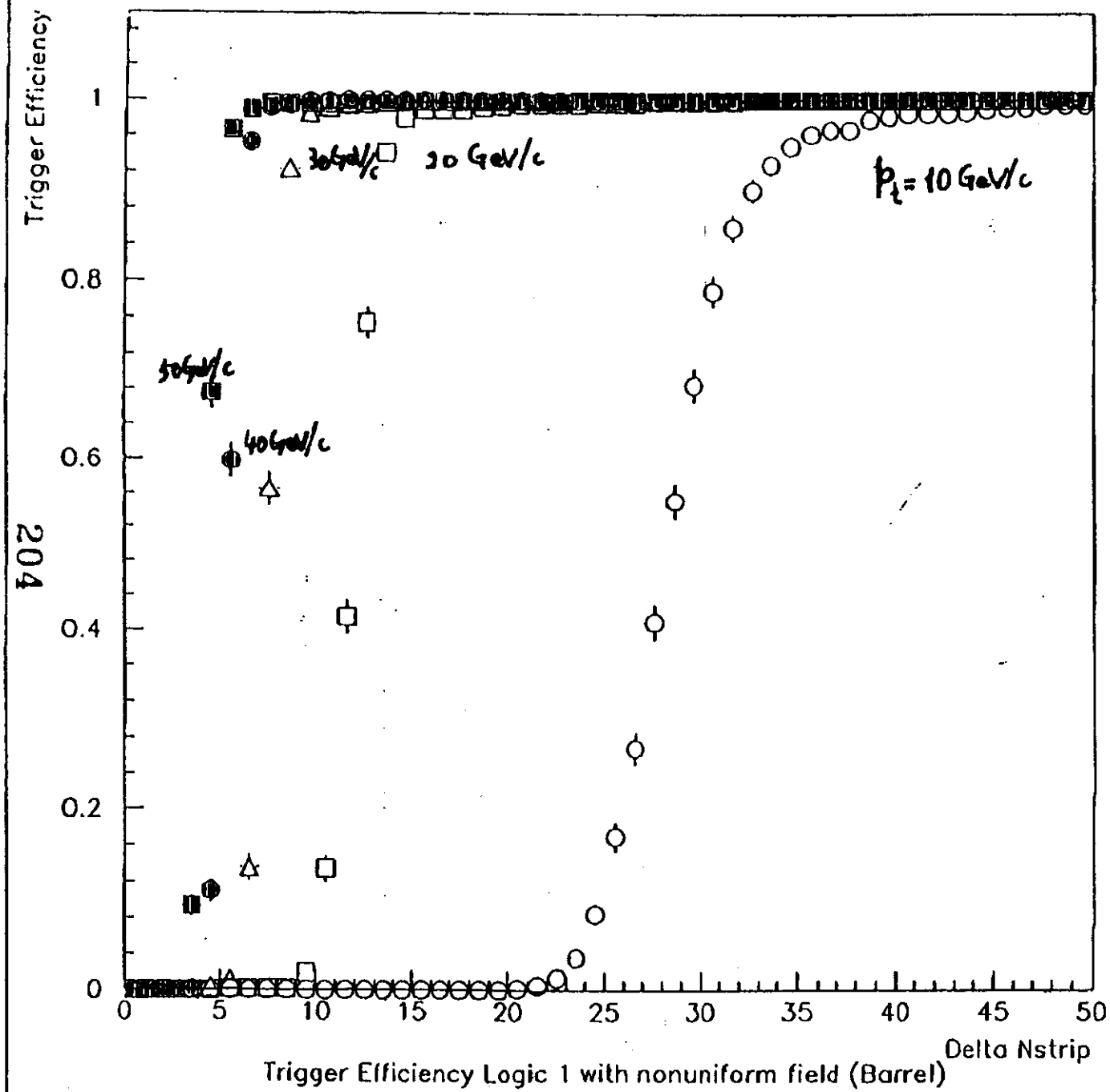
July 3, 1992
@ SSCL

Muon Trigger Study

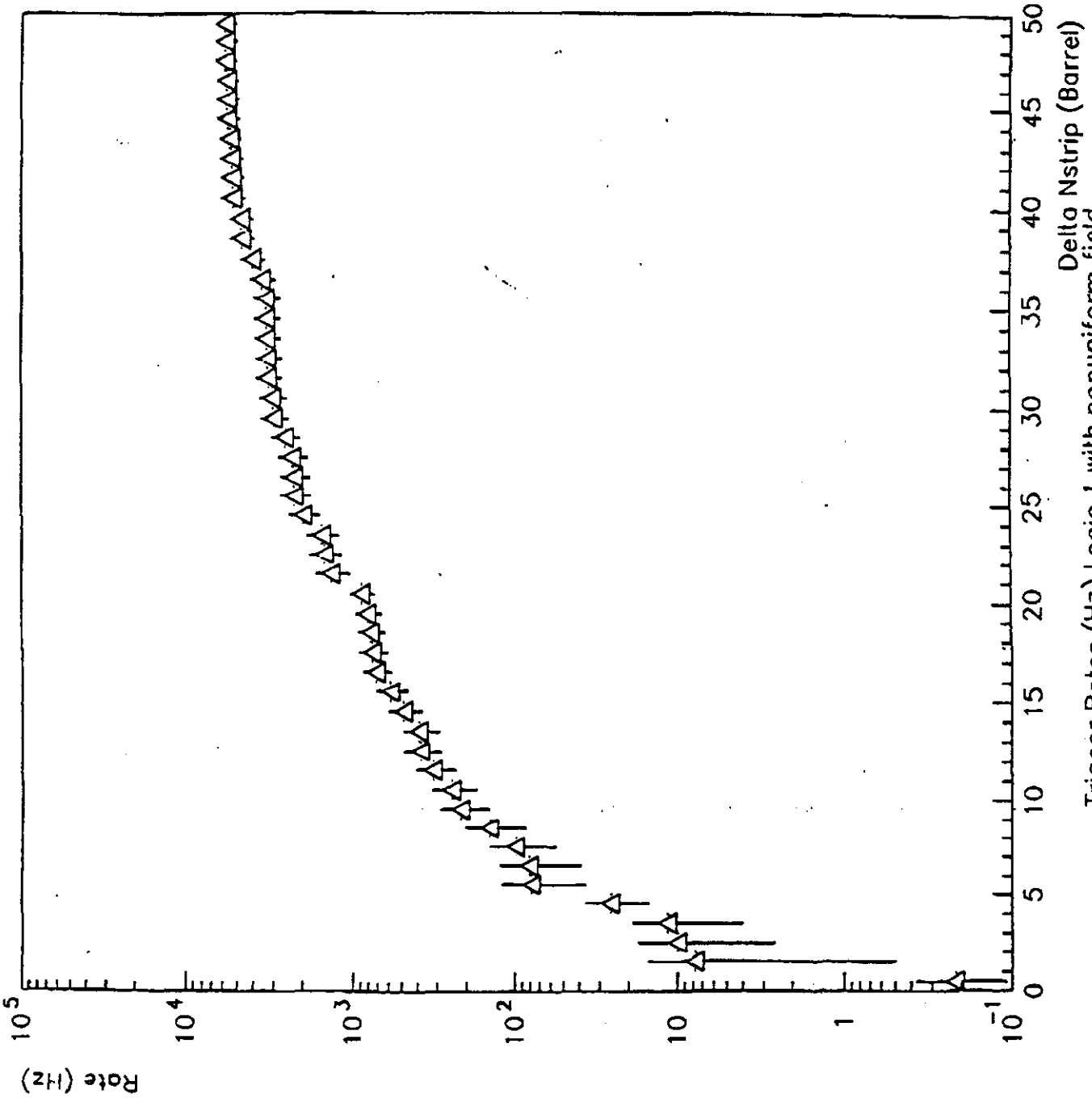
Chiaki Yanagisawa
Stony Brook.

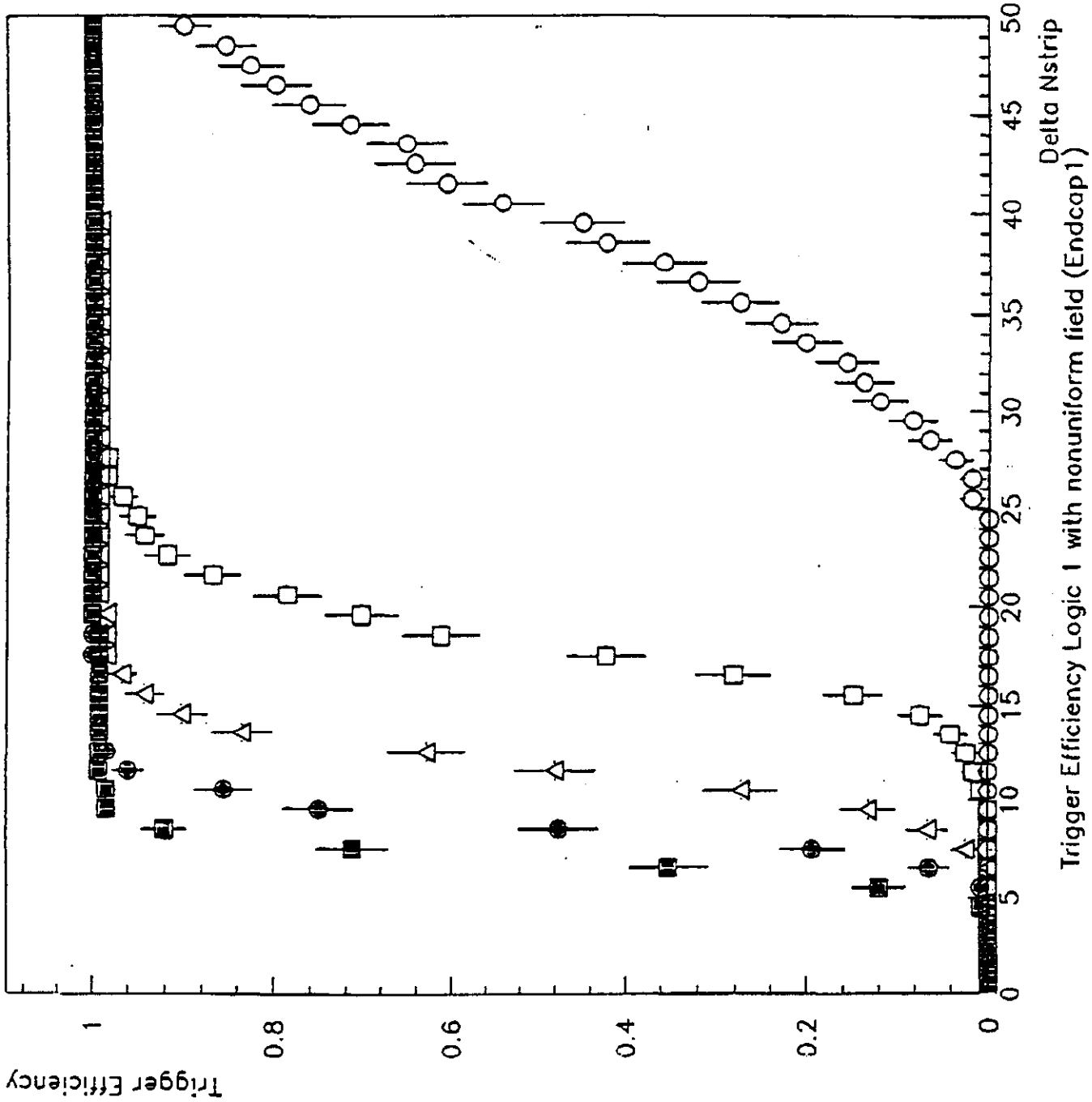


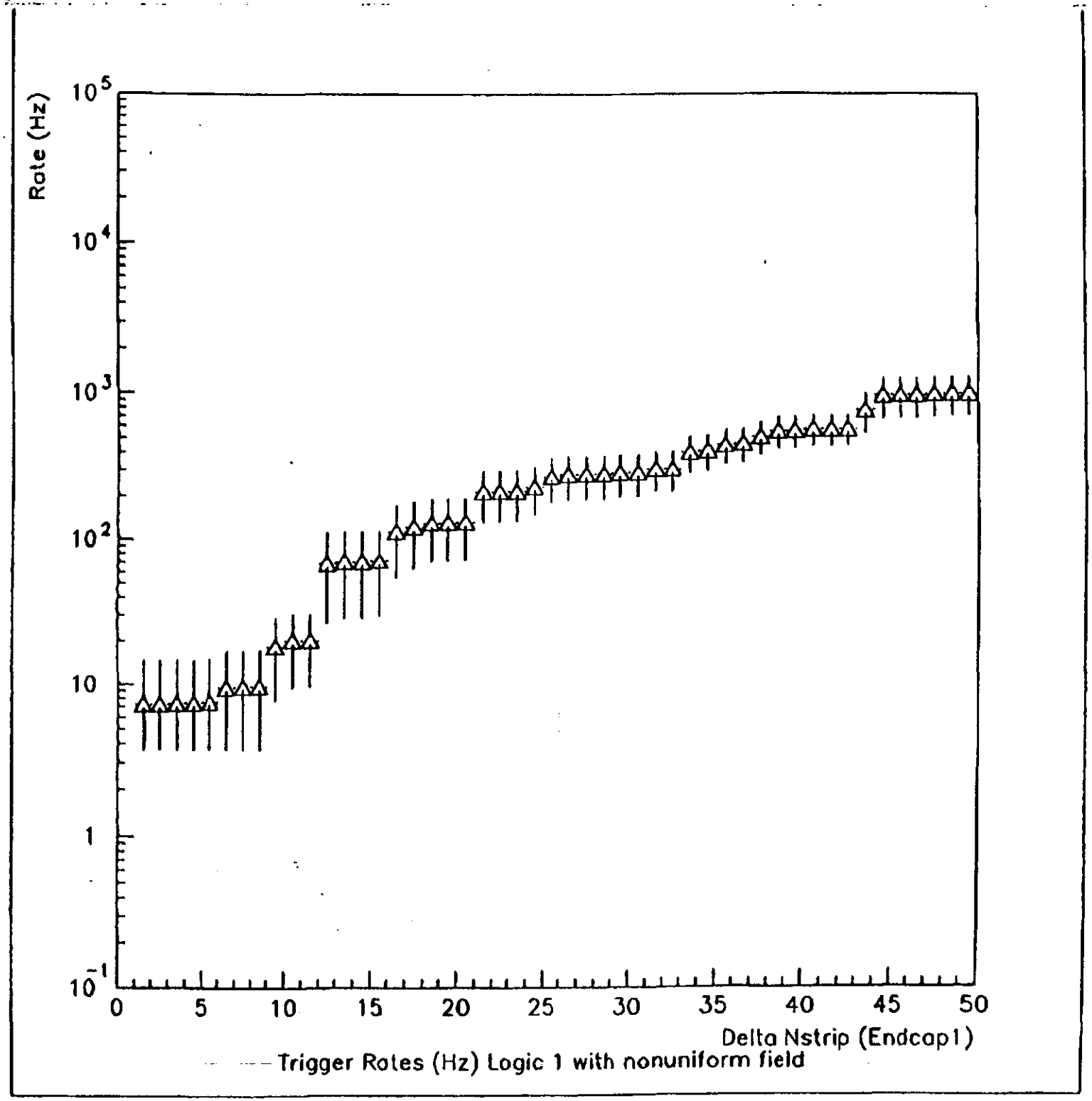
- Single layer superlayer
- No material in the muon system.
- For hadrons, PCHTHR
  For muons, full GEANT
- Non uniform B field
- For rate study,
  QCD dijet events 4GeV/c p_T < 1TeV/c

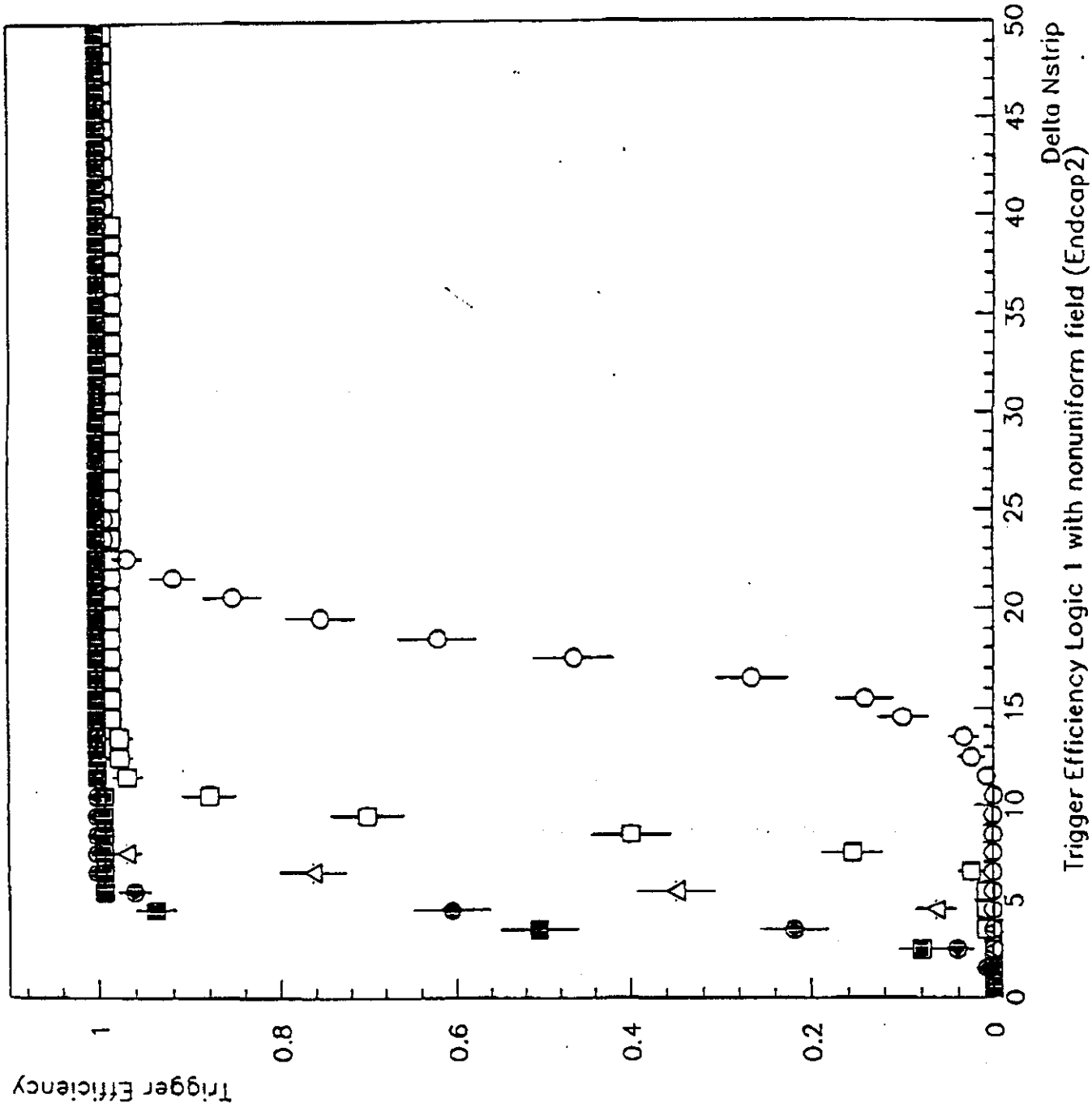


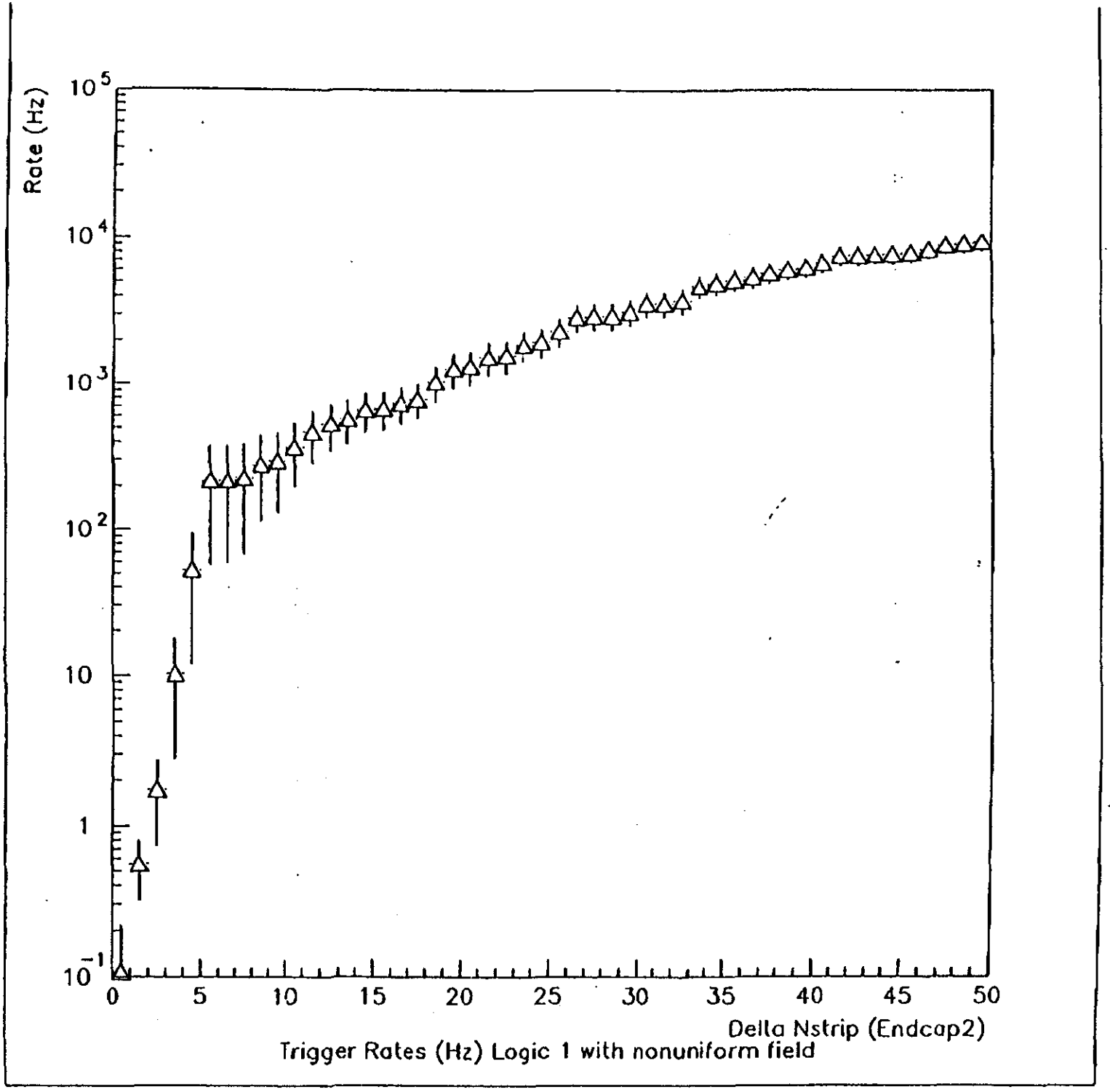
Trigger Efficiency Logic 1 with nonuniform field (Barrel)


Rate (Hz)
10^5
10^4
10^3
10^2
10
1
10^{-1}
0
5
10
15
20
25
30
35
40
45
50
Delta Nstrip (Barrel)
Trigger Rates (Hz) Logic 1 with nonuniform field


Trigger Efficiency
0
0.2
0.4
0.6
0.8
1
0
5
10
15
20
25
30
35
40
45
50
Delta Nstrip
Trigger Efficiency Logic 1 with nonuniform field (Endcap1)


Rate (Hz)
10^5
10^4
10^3
10^2
10
1
10^{-1}
0
5
10
15
20
25
30
35
40
45
50
Delta Nstrip (Endcap1)
Trigger Rates (Hz) Logic 1 with nonuniform field


Trigger Efficiency
0
0.2
0.4
0.6
0.8
1
0
5
10
15
20
25
30
35
40
45
50
Delta Nstrip
Trigger Efficiency Logic 1 with nonuniform field (Endcap2)


Rate (Hz)
10^5
10^4
10^3
10^2
10
1
10^{-1}
0
5
10
15
20
25
30
35
40
45
50
Delta Nstrip (Endcap2)
Trigger Rates (Hz) Logic 1 with nonuniform field