GEM TN-93-277

CSC Electronics and Trigger Meeting - Stony Brook

Cathode Strip Chamber Group

January 26, 1993

Abstract:

Agenda, attendees, and presentations of the GEM CSC Electronics and Trigger Meeting held at SUNY-Stony Brook on January 26, 1993.

CSC Electronics and Trigger Meeting

Stony Brook -- Tuesday Jan. 26, 1993 10:30 AM - 5:30 PM
Graduate Physics Building, Room D-118

Agenda:

- o current status of: Simulation
  Front end
  Mux/ADC
  Trigger
  Anode electronics
- o TDR assignments
- o Review of cost estimates
- o Post TDR tasks
- o A O B

M. Atiya bnl787::atiya
M. Mohammadi sbhep::mohammadi

CSC Electronics & Trigger Meeting – Stony Brook Jan 26, 93

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gem

γeμ

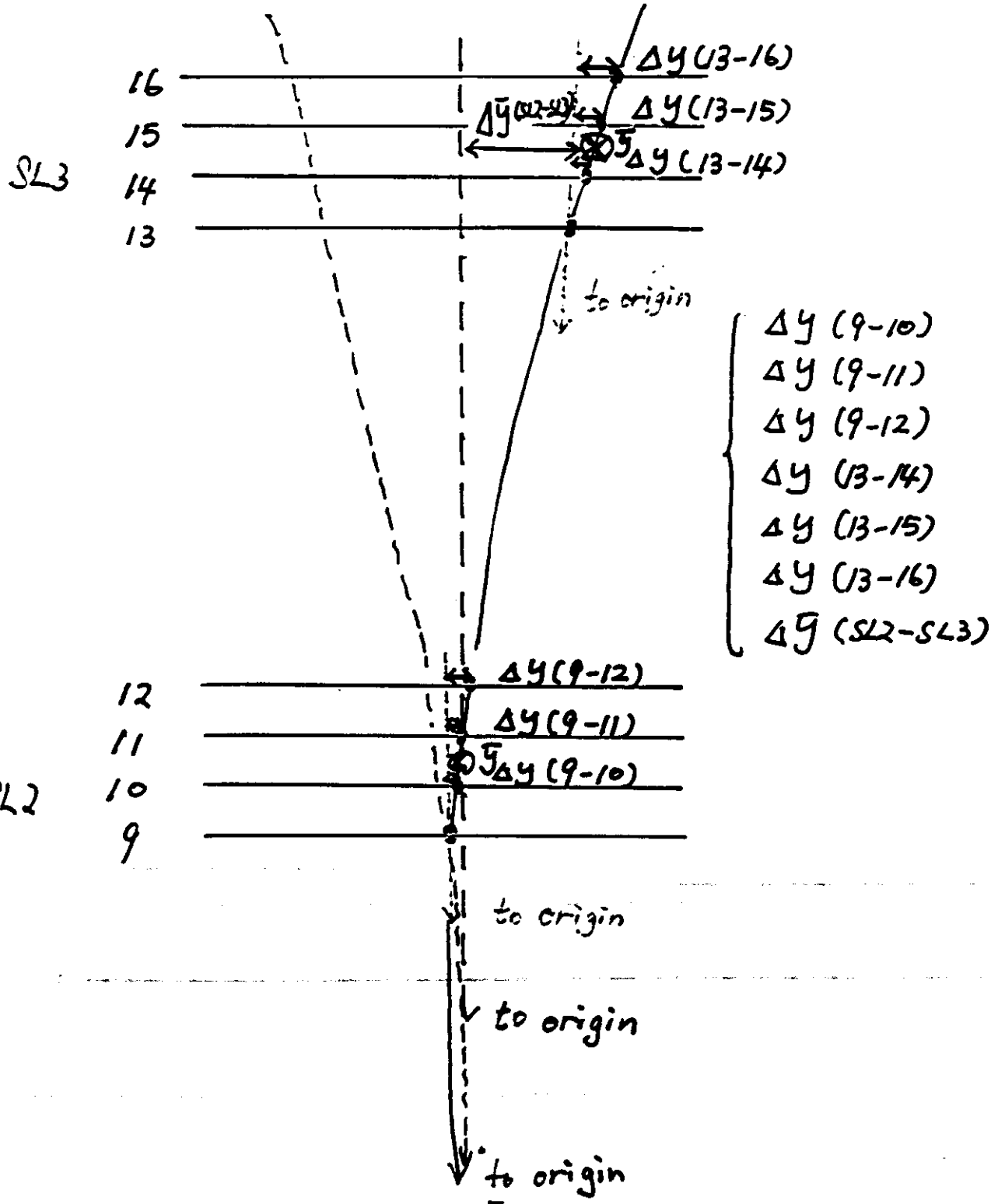
Presentation by:

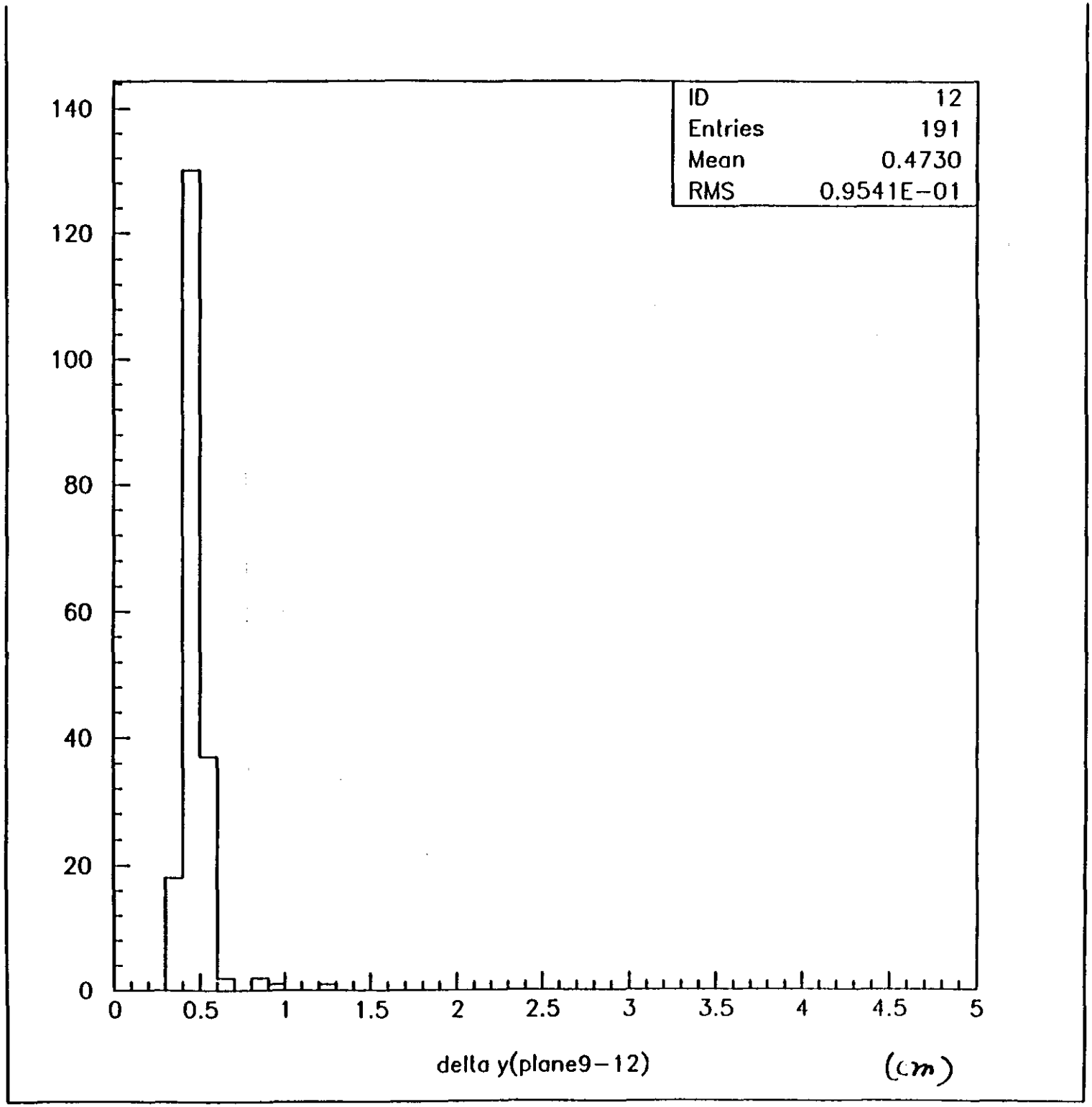
Chiaki Yanagisawa

Barrel trigger simulation with multilayer super-layers

Chiaki Yanagisawa
1/26/93
at Stony Brook.

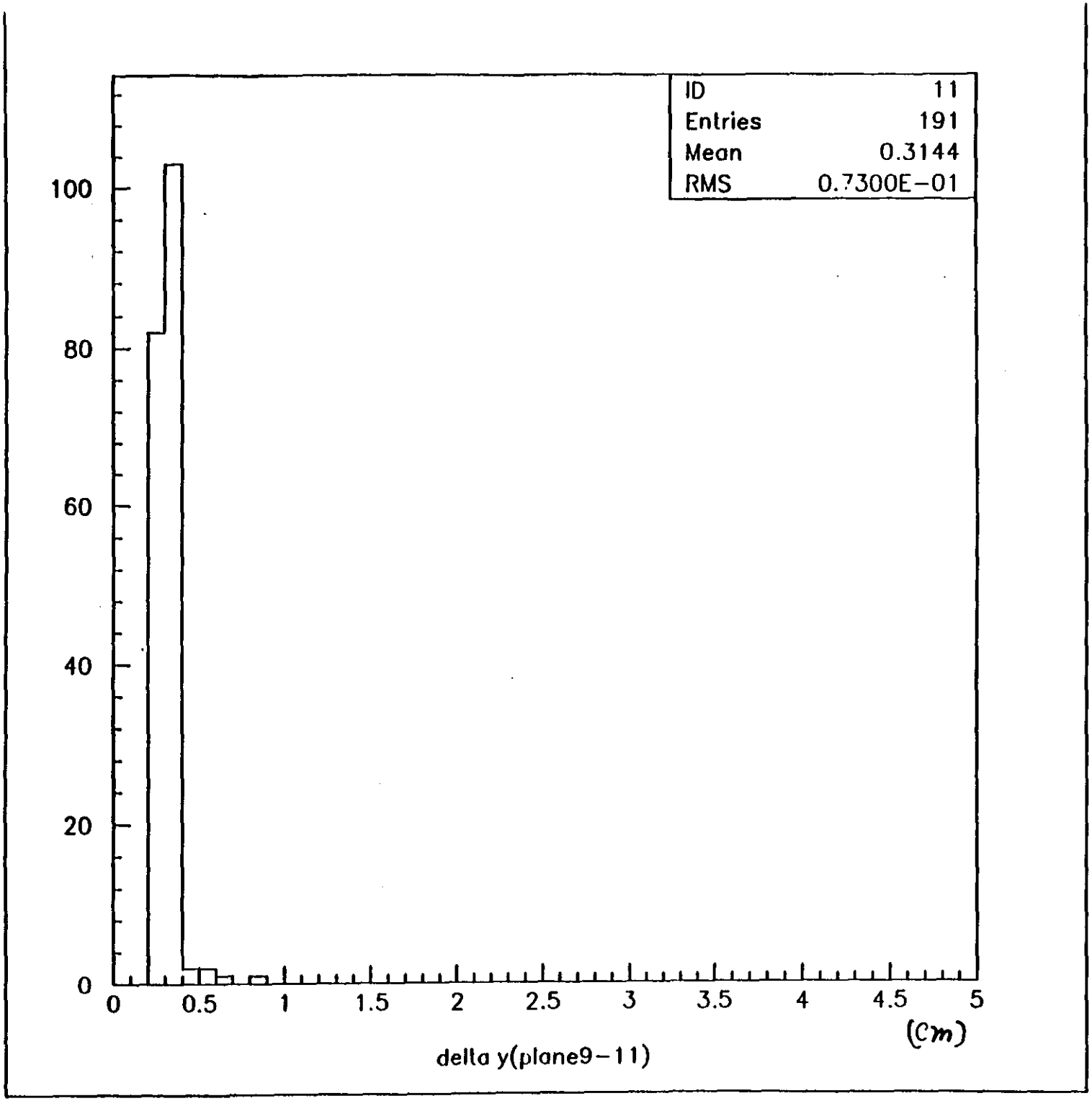
- Old configuration of 8-4-4
- MC data: single μ with $p_T = 20, 30, 40, 50$ GeV/c





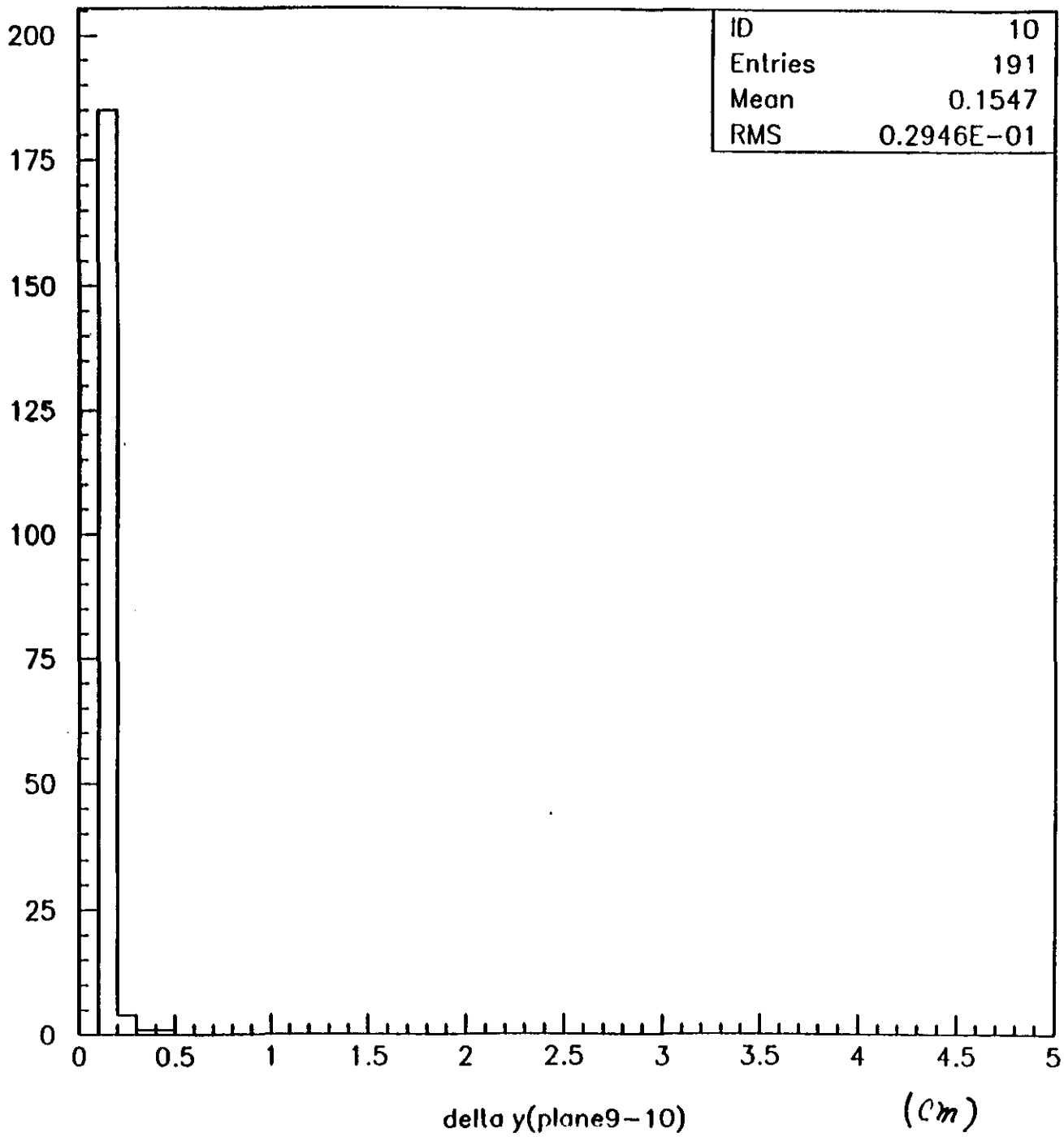
SL2

$p_T = 20$ GeV/c



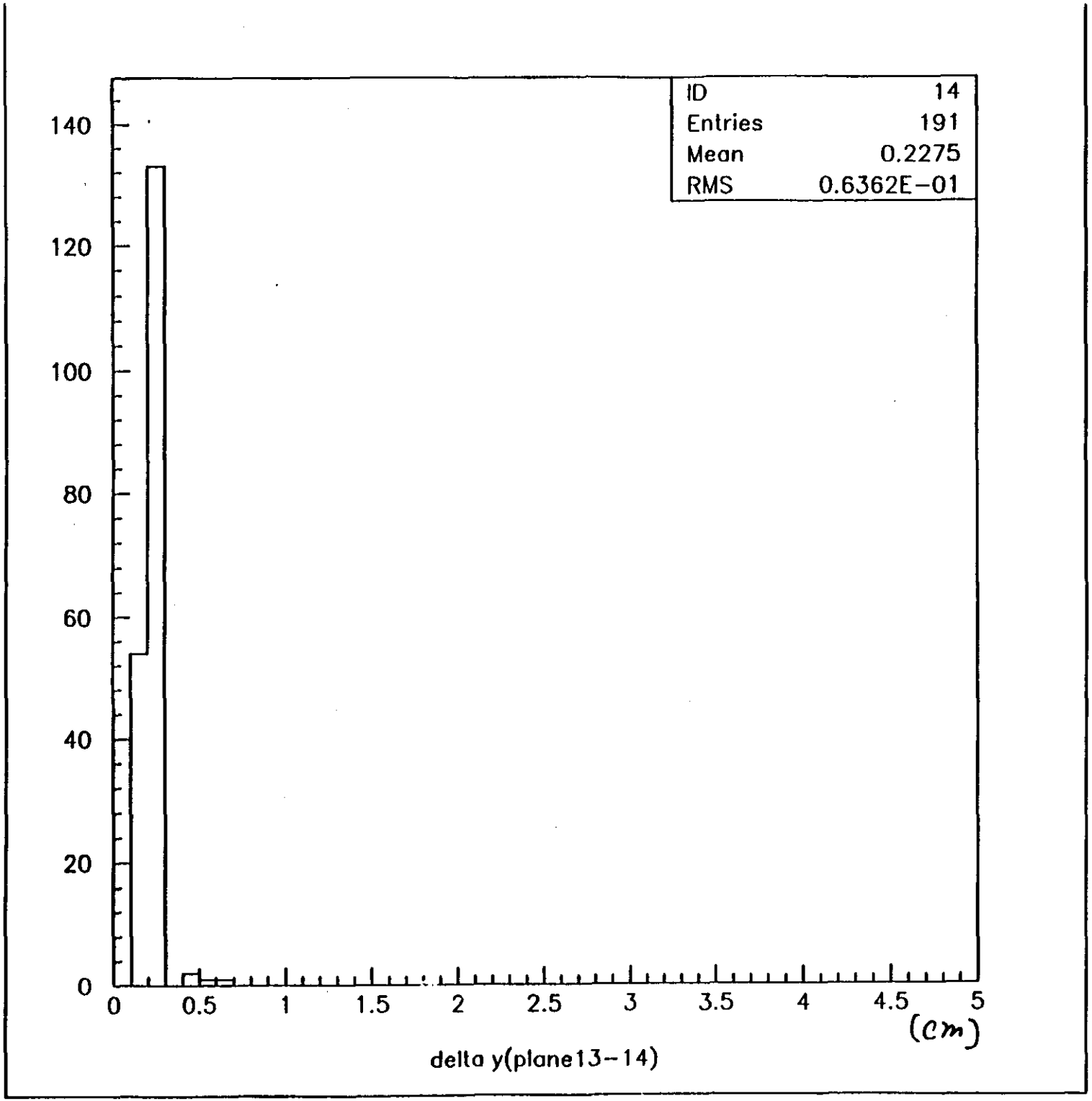
SL3

$p_T = 20 GeV/c$



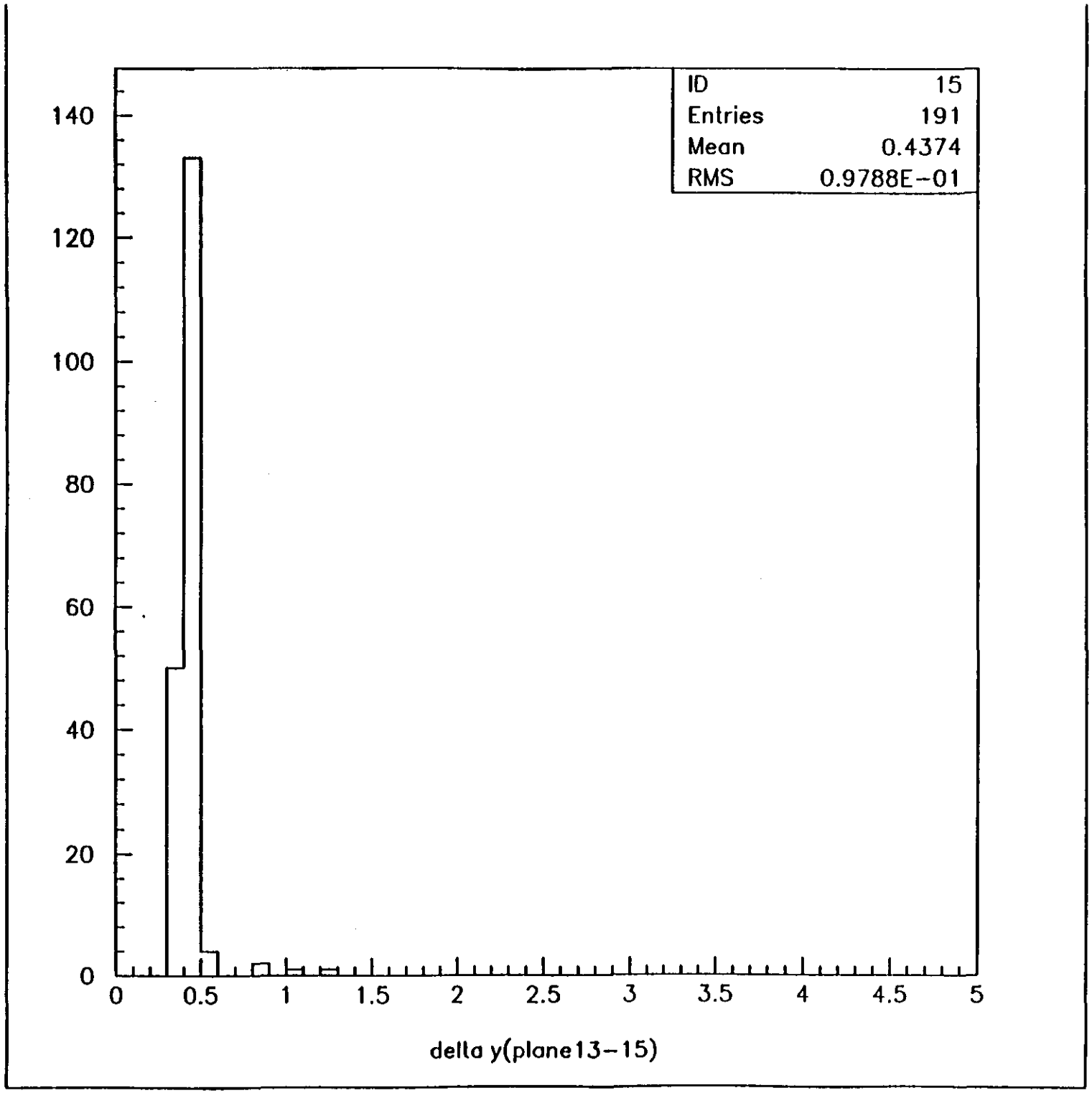
9L2

$p_T = 20 GeV/c$



SL3

$p_T = 20 GeV/c$

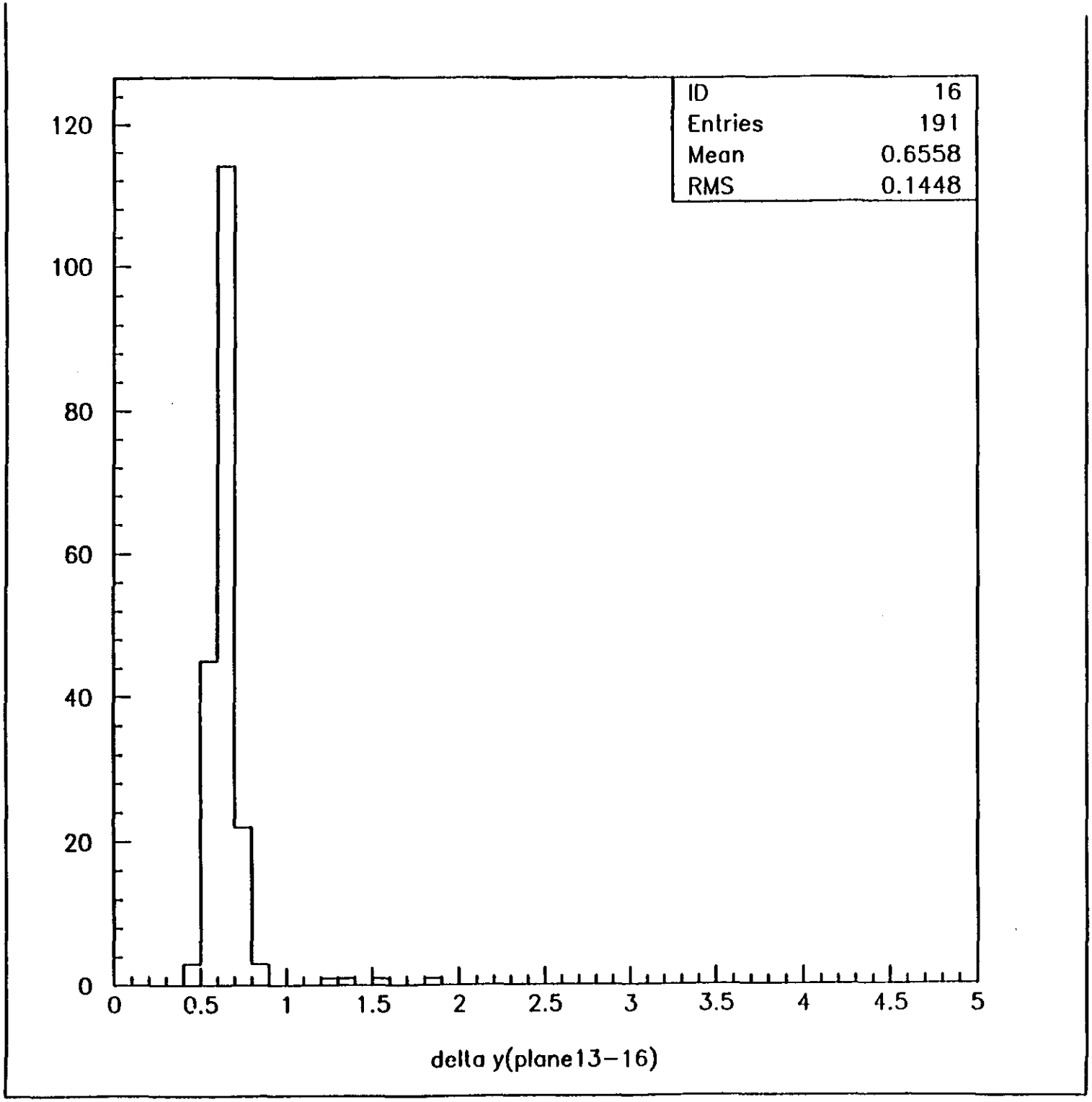


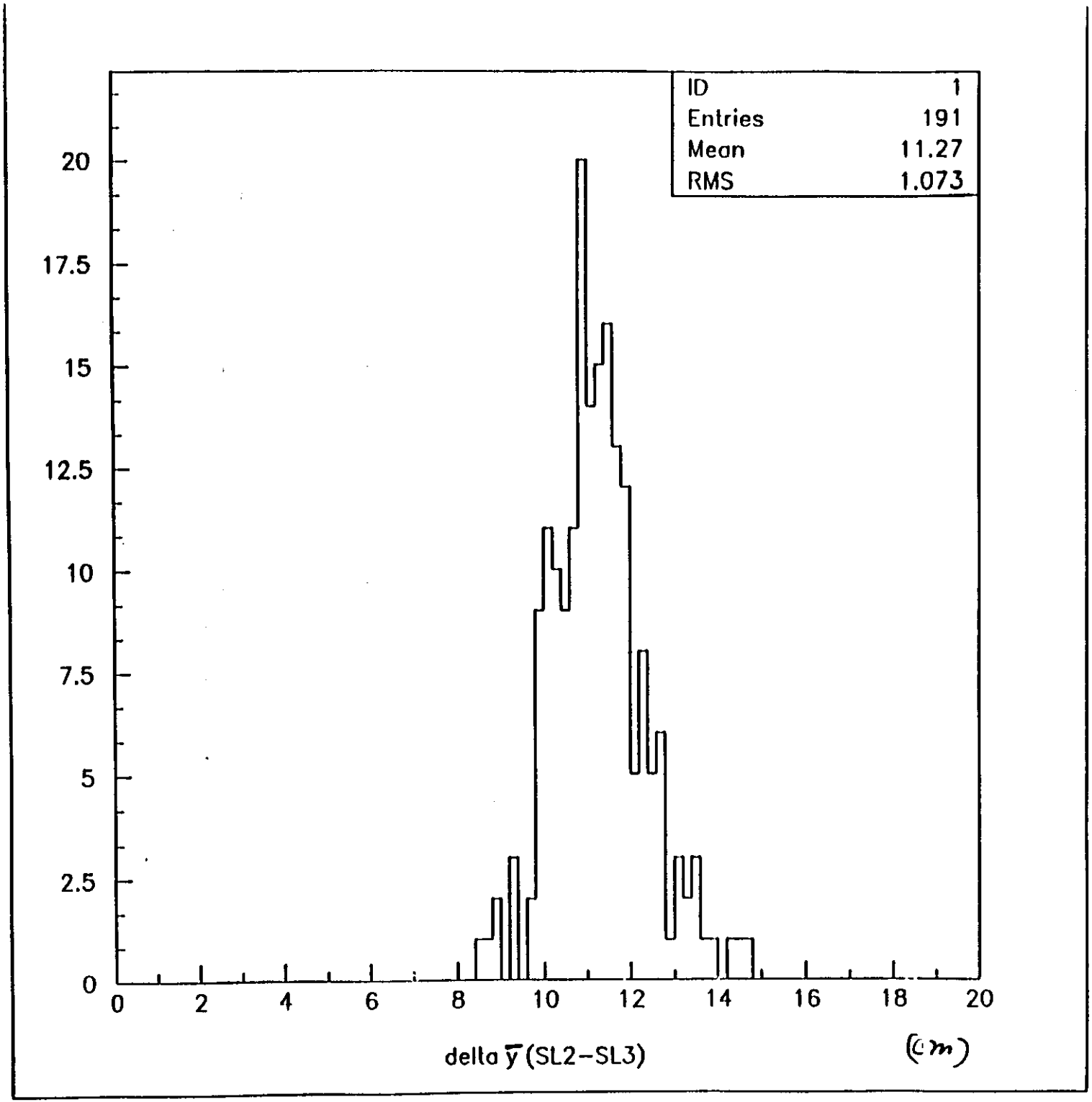
SL3

$p_T = 2.0$ GeV/c

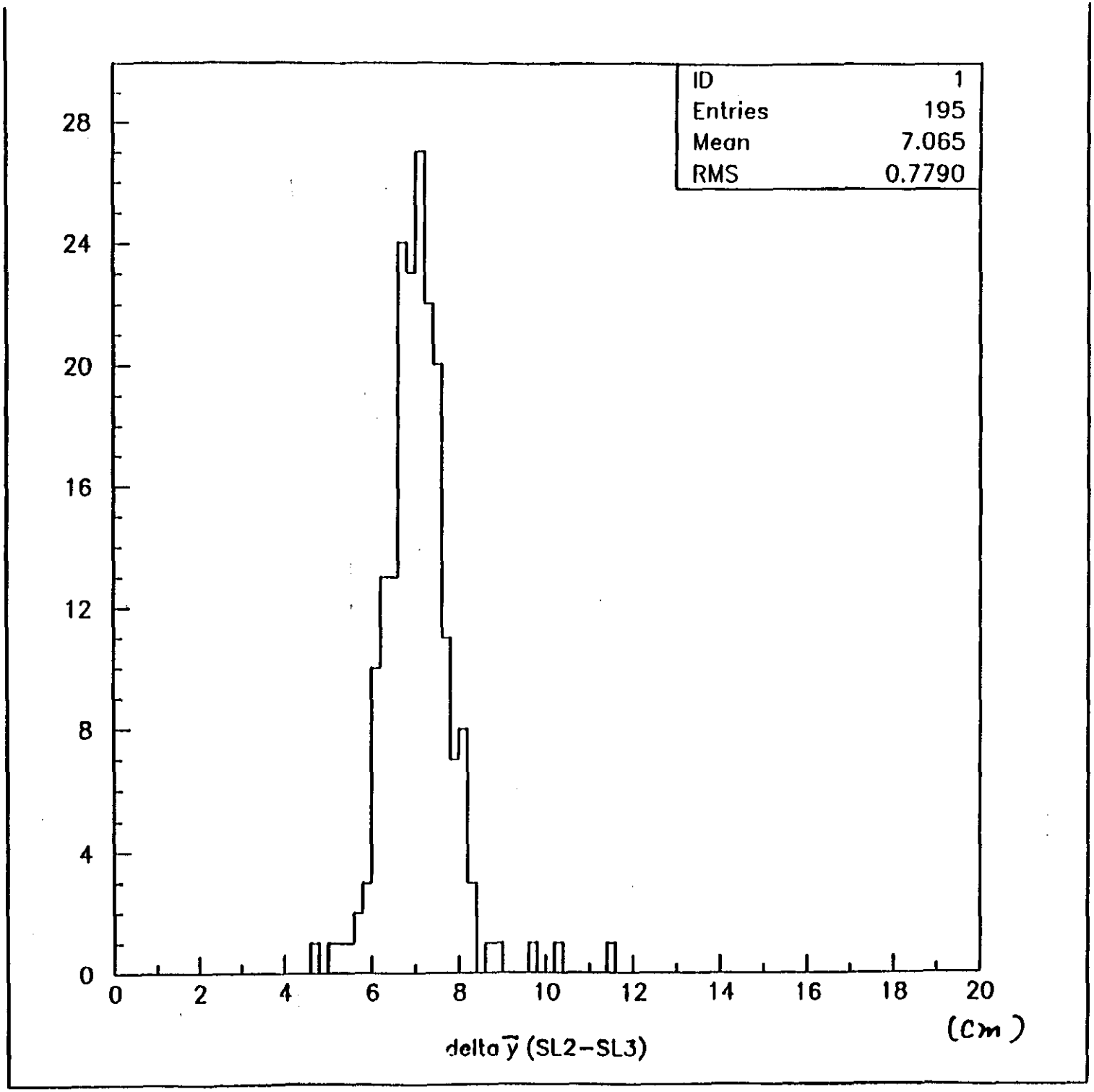
SL3

$p_T = 20 GeV/c$

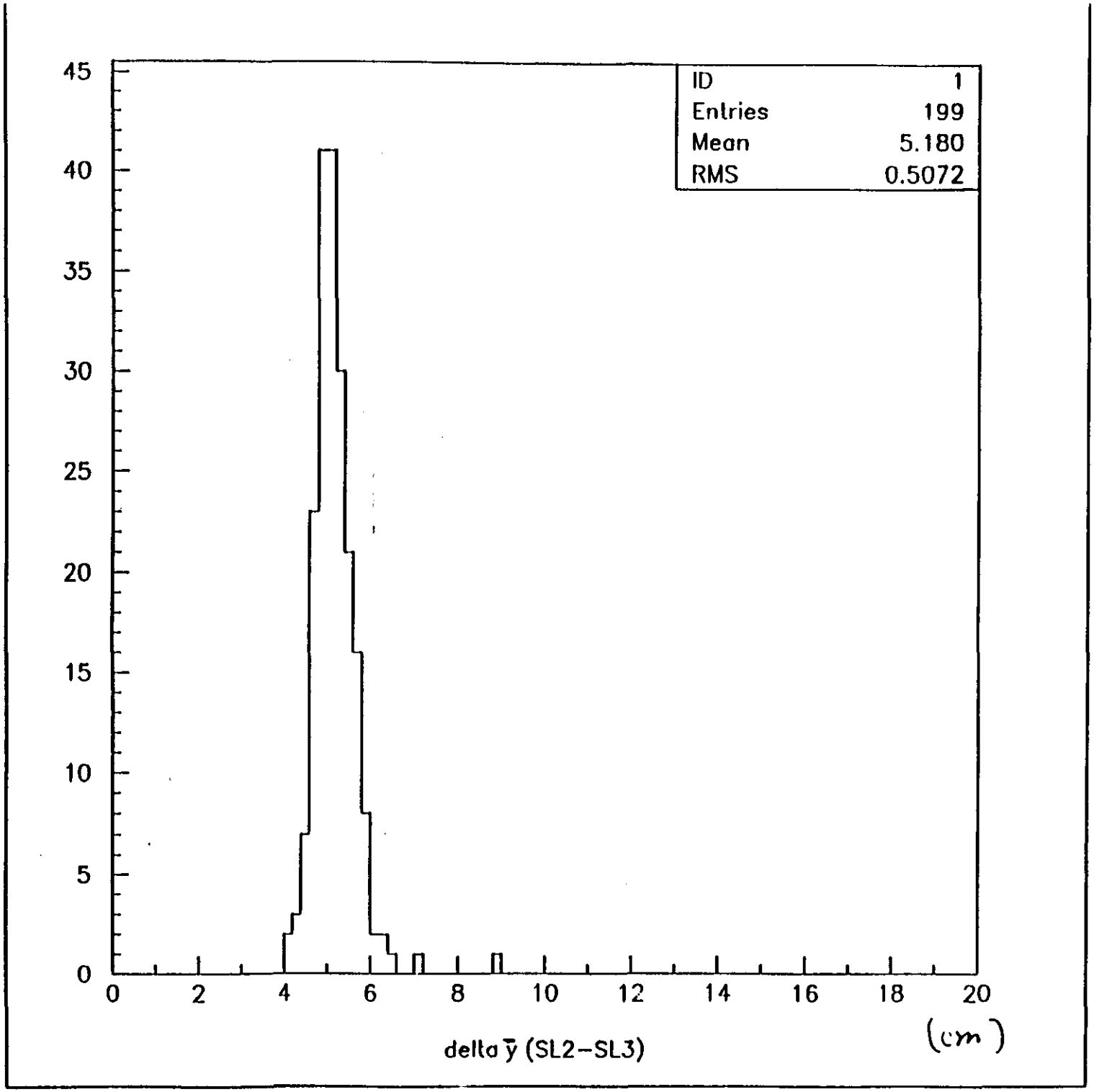



ID 1
Entries 191
Mean 11.27
RMS 1.073
20
17.5
15
12.5
10
7.5
5
2.5
0
0 2 4 6 8 10 12 14 16 18 20
delta $\bar{y}$ (SL2−SL3)
(cm)

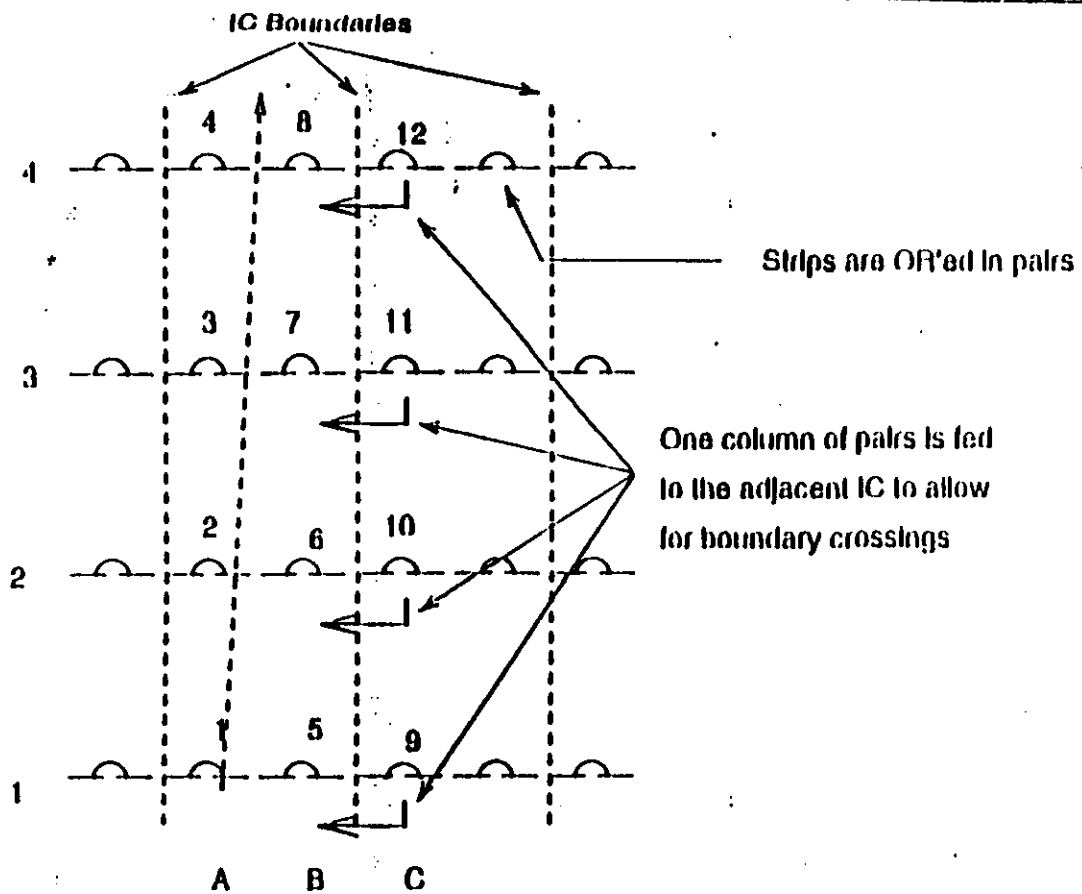
$p_T = 20$ GeV/c

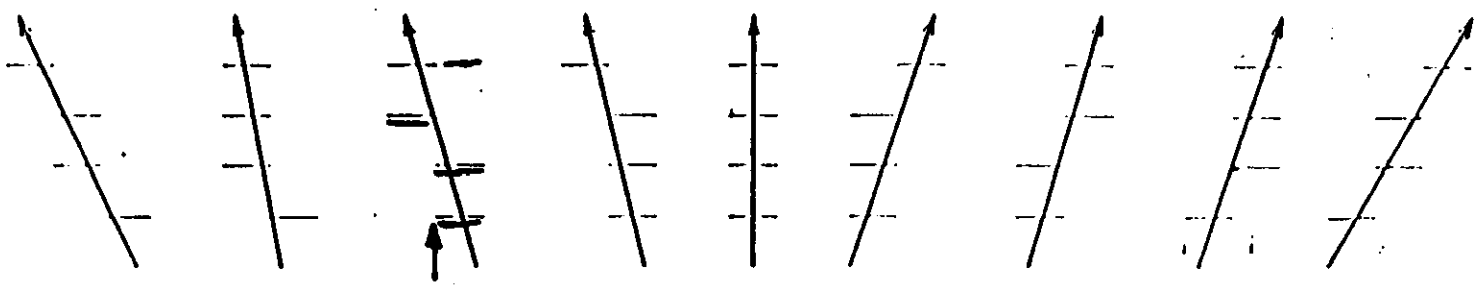

ID 1
Entries 195
Mean 7.065
RMS 0.7790
0
4
8
12
16
20
24
28
0
2
4
6
8
10
12
14
16
18
20
delta $\bar{y}$ (SL2−SL3)
(cm)

$p_T = 30$ GeV/c

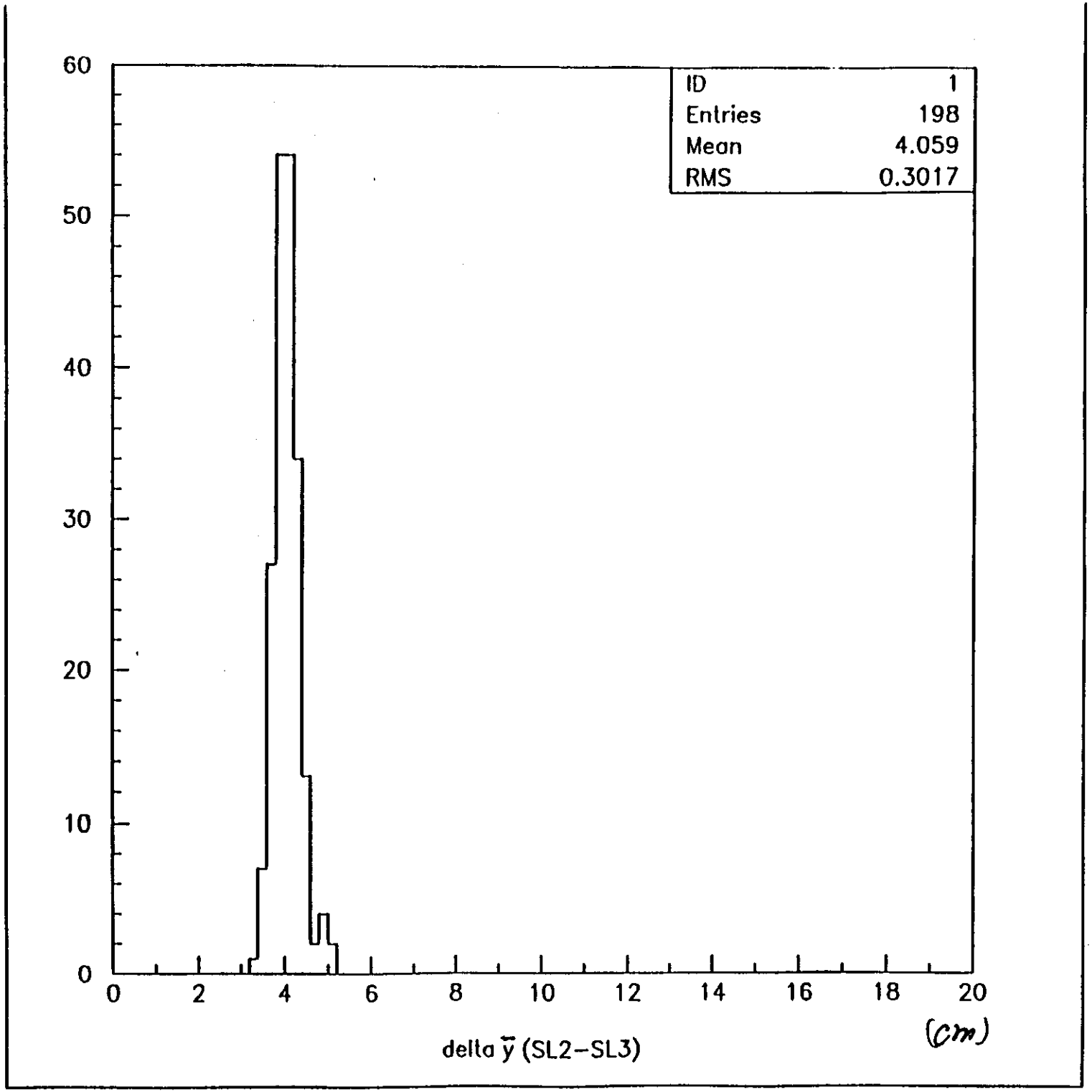

ID 1
Entries 199
Mean 5.180
RMS 0.5072
45
40
35
30
25
20
15
10
5
0
0
2
4
6
8
10
12
14
16
18
20
delta ȳ (SL2−SL3)
(cm)

$p_T = 40$ GeV/c

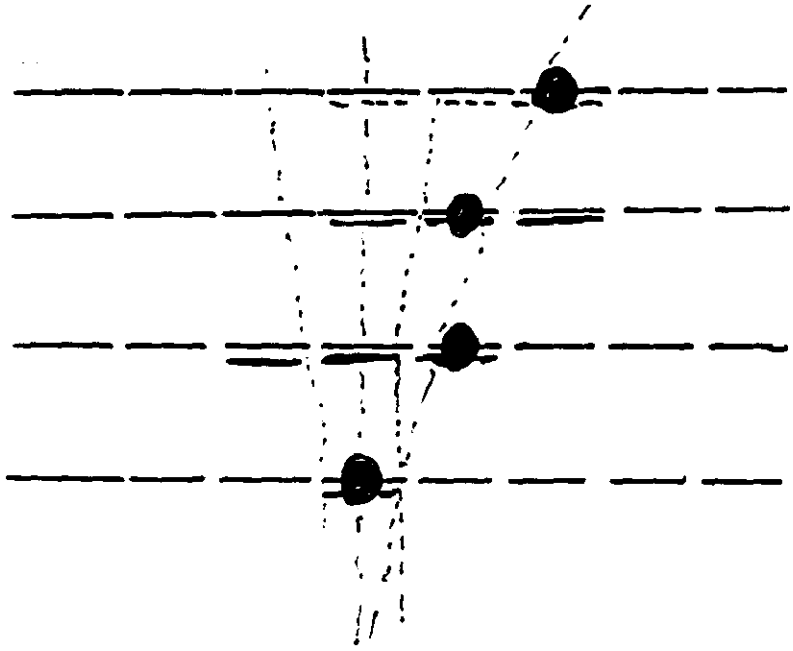




Possible Tower Combinations


ID 1
Entries 198
Mean 4.059
RMS 0.3017
60
50
40
30
20
10
0
0 2 4 6 8 10 12 14 16 18 20
delta ỹ (SL2−SL3)
(cm)

$p_T = 50\,GeV$



$$\left({}_3C_4 \times 3^2\right)^2 \times N_{strip}^{SL2} \times \Delta N_{strip}^{SL2-SL3}$$

3 out of 4 layers
"
4

without knowledge of direction in a superlayer.

$\pm 15^{cm}$ for 20 GeV/c
$\pm 12^{cm}$ for 30
$\pm 10^{cm}$ for 40.
$\oplus$
"strip width"

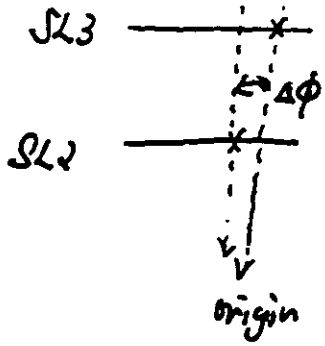
1/28/93

Chiaki Yanagisawa
Stony Brook

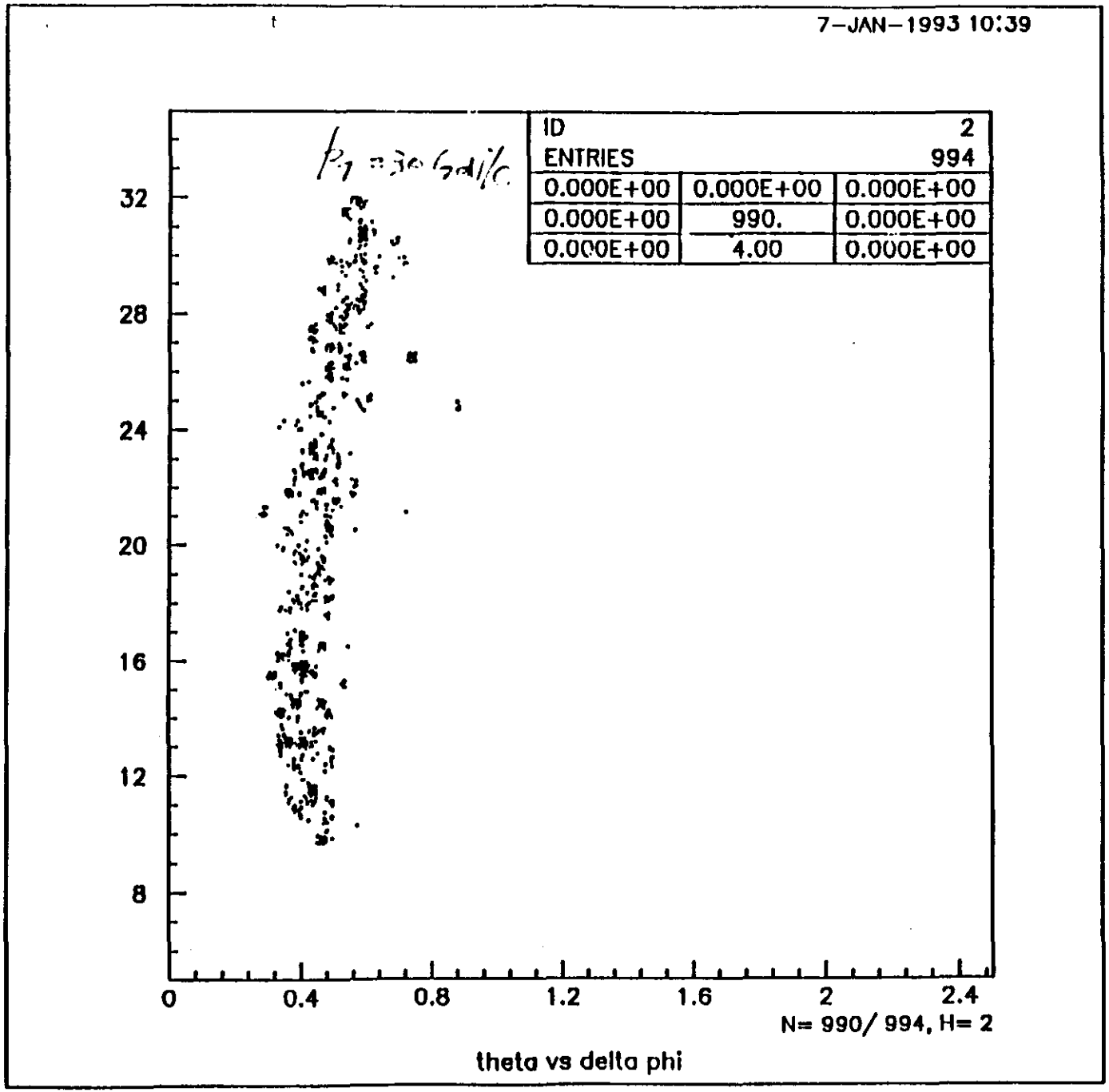
θ dependence of $\Delta\phi$ in Endcap region.

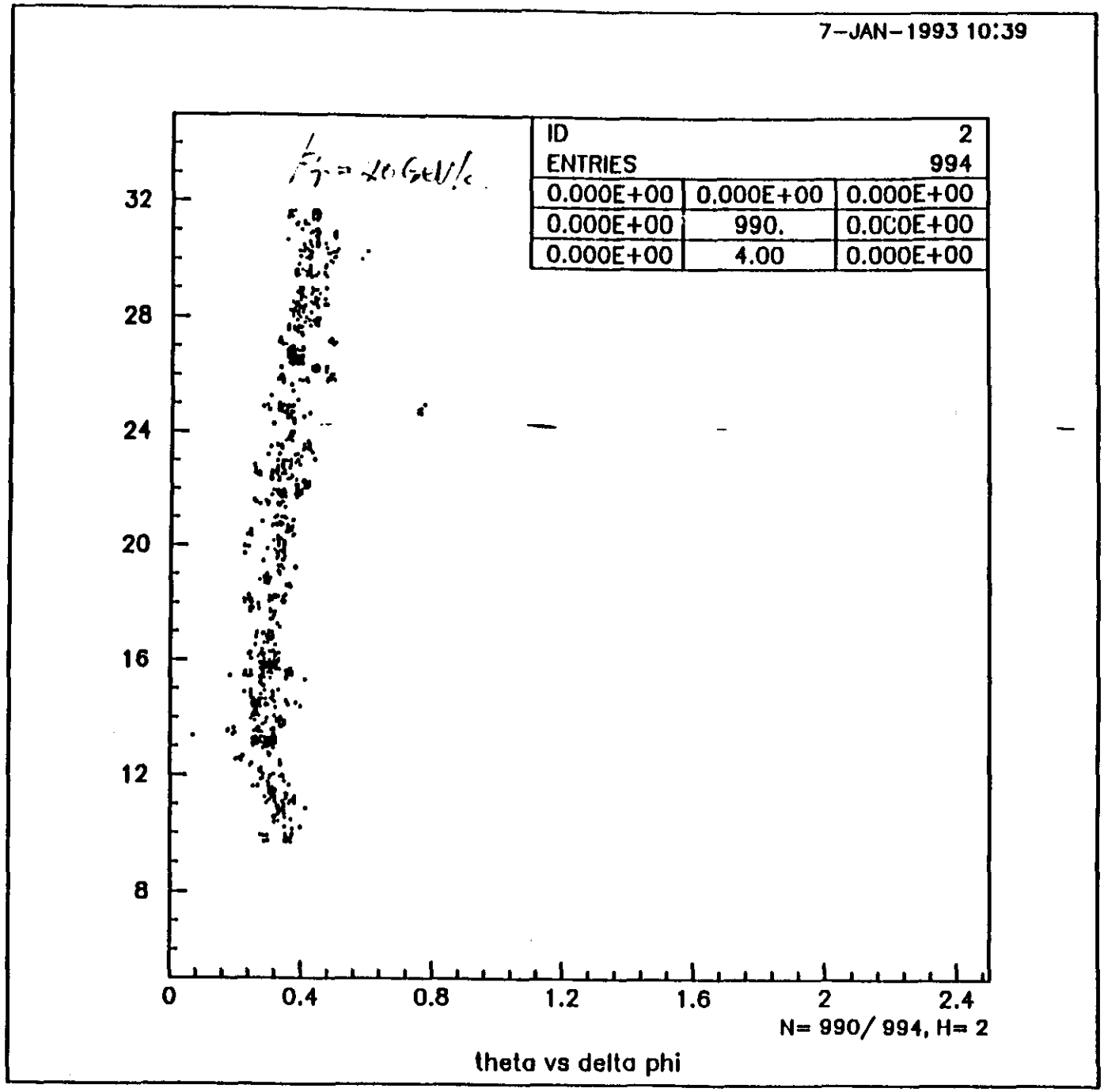
$$\Delta\phi \equiv \phi'_{SL3} - \phi'_{SL2}$$

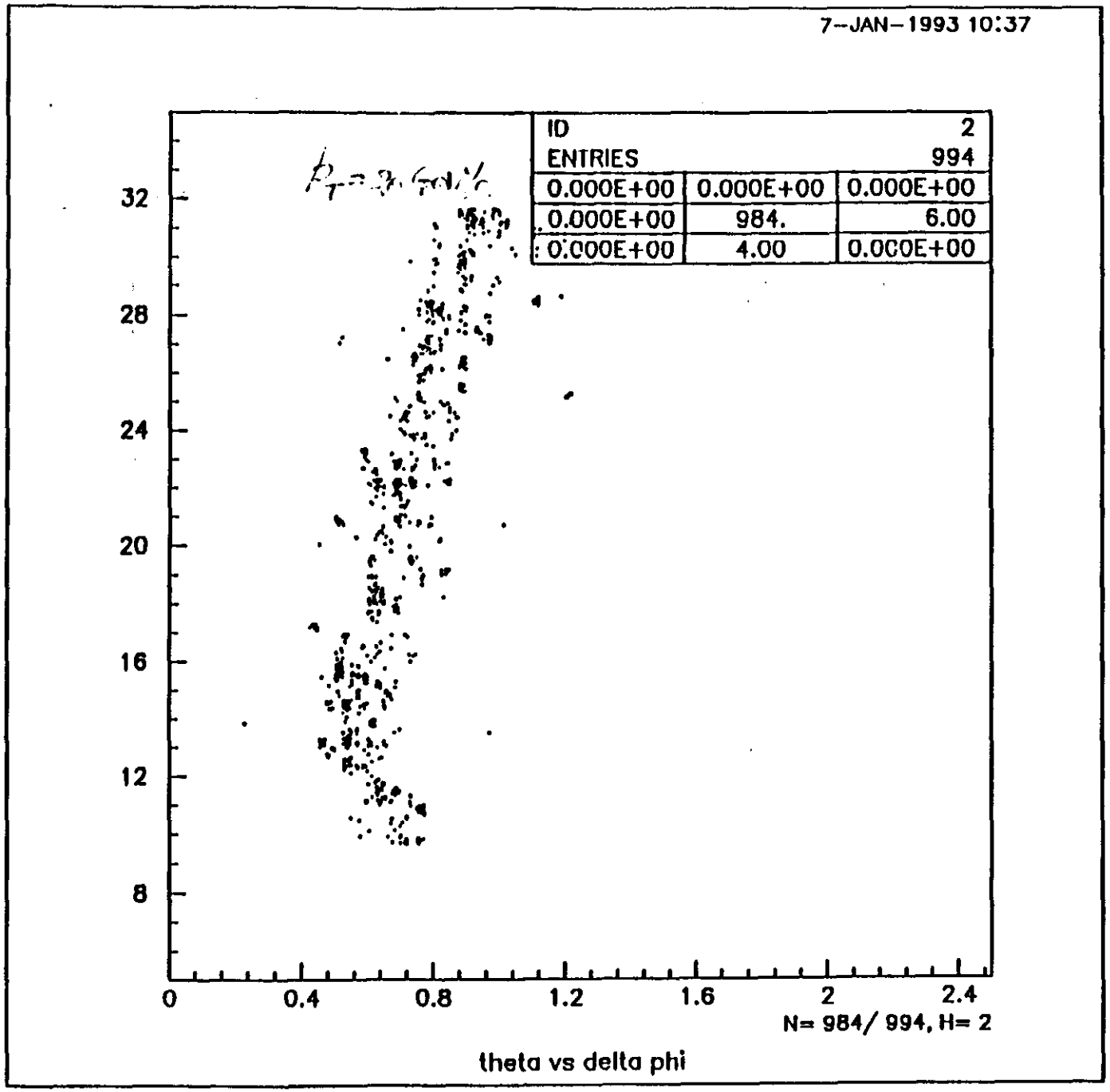
for fixed p_T muons in Endcap.
with non-uniform mag. field.

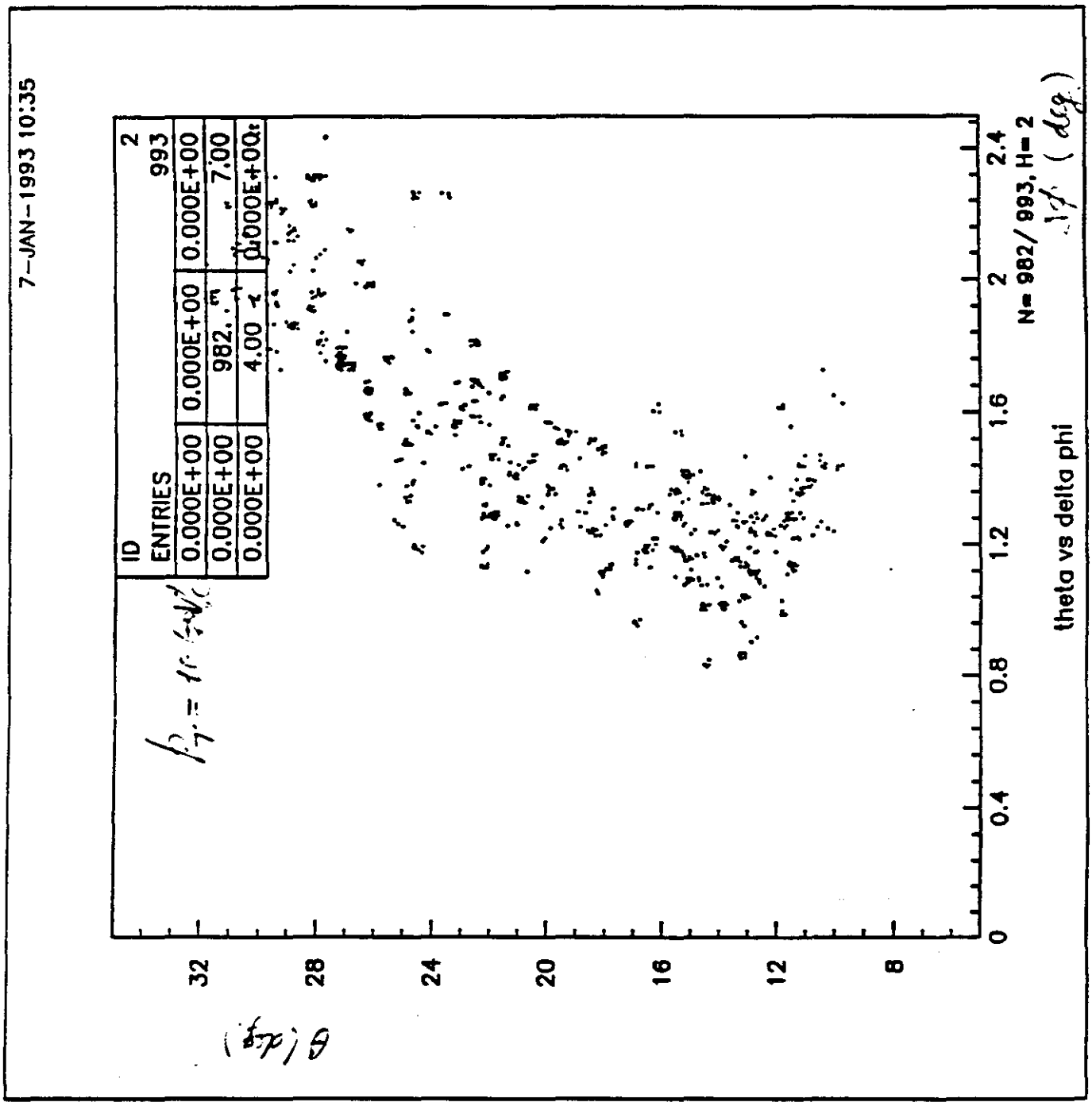


$$s \sim \frac{\theta}{p_T}$$


7-JAN-1993 10:39
ID 2
ENTRIES 994
0.000E+00 0.000E+00 0.000E+00
0.000E+00 990. 0.000E+00
0.000E+00 4.00 0.000E+00
32
28
24
20
16
12
8
0
0.4
0.8
1.2
1.6
2
2.4
N= 990/ 994, H= 2
theta vs delta phi


7-JAN-1993 10:39
ID 2
ENTRIES 994
0.000E+00 0.000E+00 0.000E+00
0.000E+00 990. 0.000E+00
0.000E+00 4.00 0.000E+00
32
28
24
20
16
12
8
0
0.4
0.8
1.2
1.6
2
2.4
N= 990/ 994, H= 2
theta vs delta phi


7-JAN-1993 10:37
ID 2
ENTRIES 994
0.000E+00 0.000E+00 0.000E+00
0.000E+00 984. 6.00
0.000E+00 4.00 0.000E+00
32
28
24
20
16
12
8
0
0.4
0.8
1.2
1.6
2
2.4
N= 984/ 994, H= 2
theta vs delta phi


7-JAN-1993 10:35
ID 2
ENTRIES 993
0.000E+00 0.000E+00 0.000E+00
0.000E+00 982. 7.00
0.000E+00 4.00 0.000E+00
32
28
24
20
16
12
8
0
0.4
0.8
1.2
1.6
2
2.4
theta vs delta phi
N= 982/ 993, H= 2

gem

γeμ

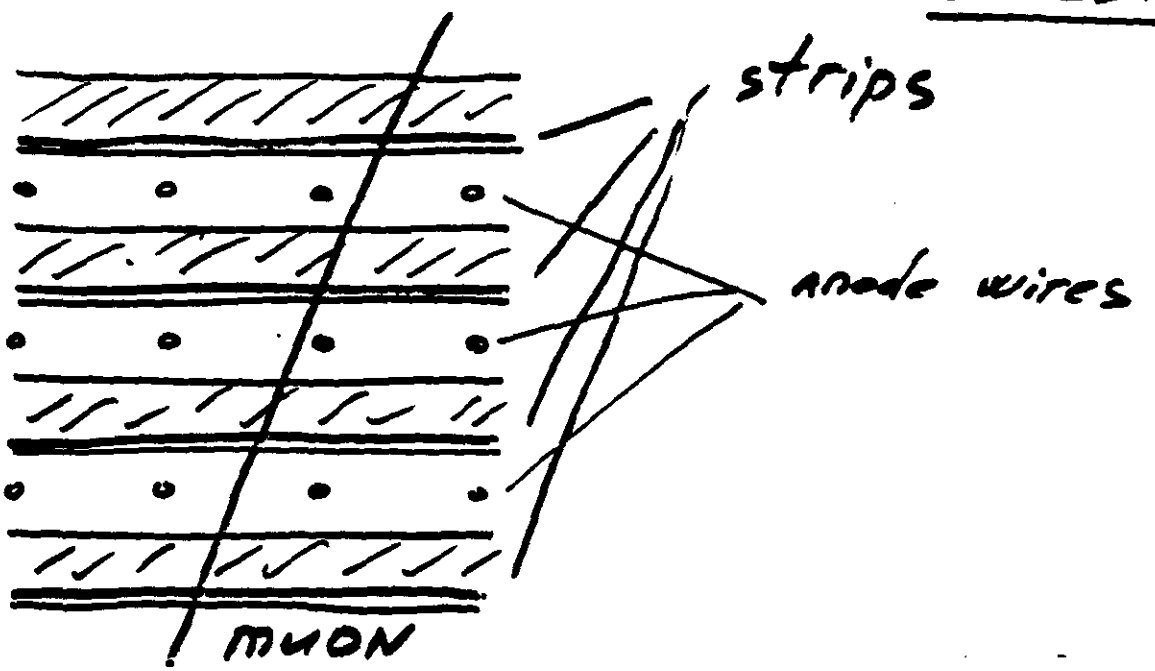
Presentation by:

Paul Murat

MONTE CARLO study OF CSC time RESOLUTION

P. MURAT
01/26/93
Stony Brook

1. CSC-based TRIGGER: QUESTIONS



* WHAT SIGNAL TO USE: FIRST

TRIGGER = OR $(t_1, \dots, t_n)$

OR

TRIGGER = MEAN$(t_1, \dots, t_n) = \frac{t_1 + \dots + t_n}{n}$

"CENTER OF GRAVITY" (Varobyov)

OR

TRIGGER = ?

* WHAT ARE THE FACTORS LIMITING CSC based TRIGGER timing EFFICIENCY? HOW can WE improve it?

2. MC study

* 2 different types of chamber GEOMETRY: "PERIODIC" and "APERIODIC"
* WIRES SHIFTED BY 0.25 pitch
* DRIFT TIMES RECONSTRUCTED FROM EXPERIMENTAL TIME SPECTRA
* EFFICIENCIES WERE DEFINED FOR

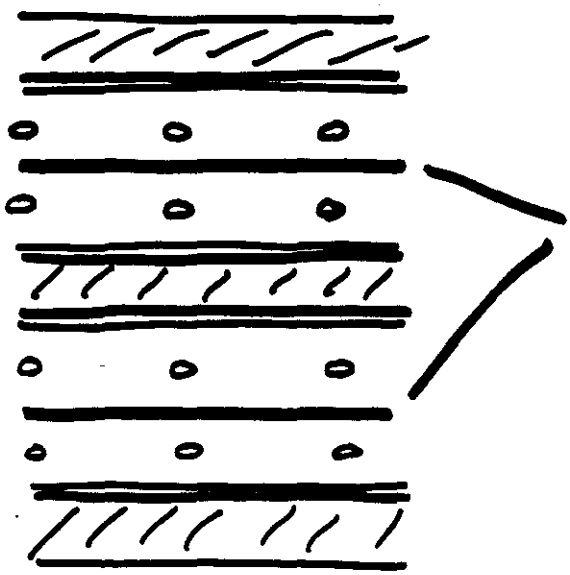
$$T = OR(t_1, \ldots t_n)$$
$$T = MEAN(t_1, \ldots, t_n)$$

t_i – time, CORRESPONDING TO "first" arriving ELECTRON, NOT TO "CENTER OF GRAVITY"

* BNL and PNPI data WERE analyzed

* WHAT CHAMBER GEOMETRY TO USE?

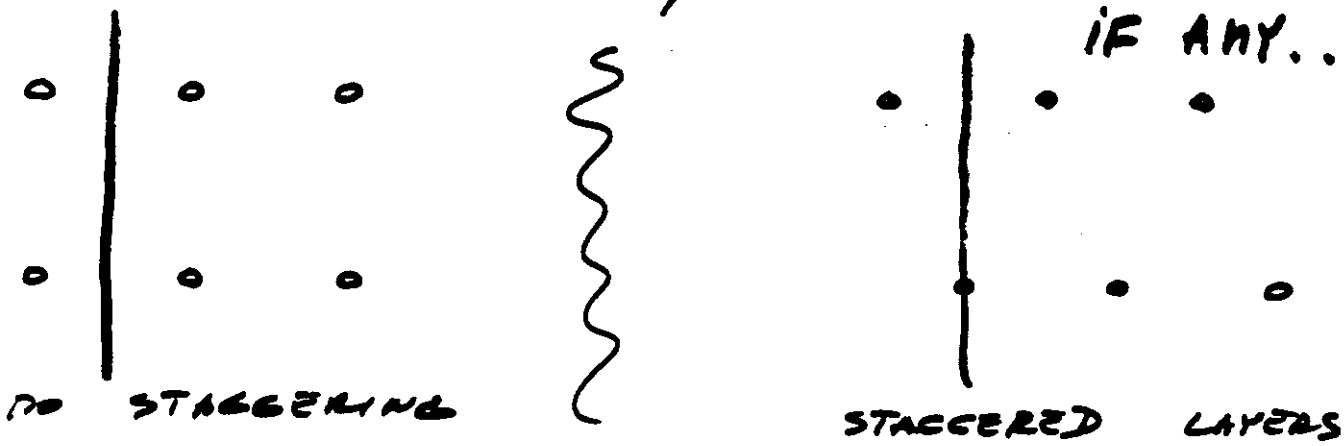
(Kirioushin)



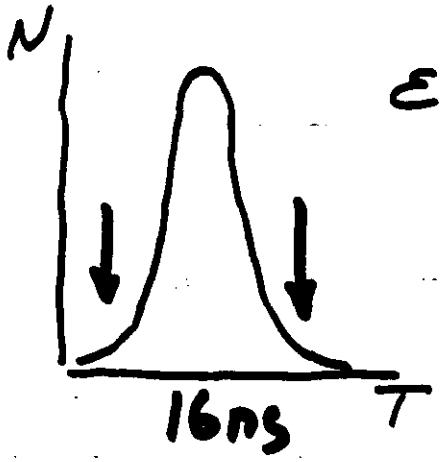
aluminum HONEYCOMB

CHAMBER is ~1.5 TIMES more thin

* DO WE NEED STAGGERING?
How does it improve timing?
IF ANY...



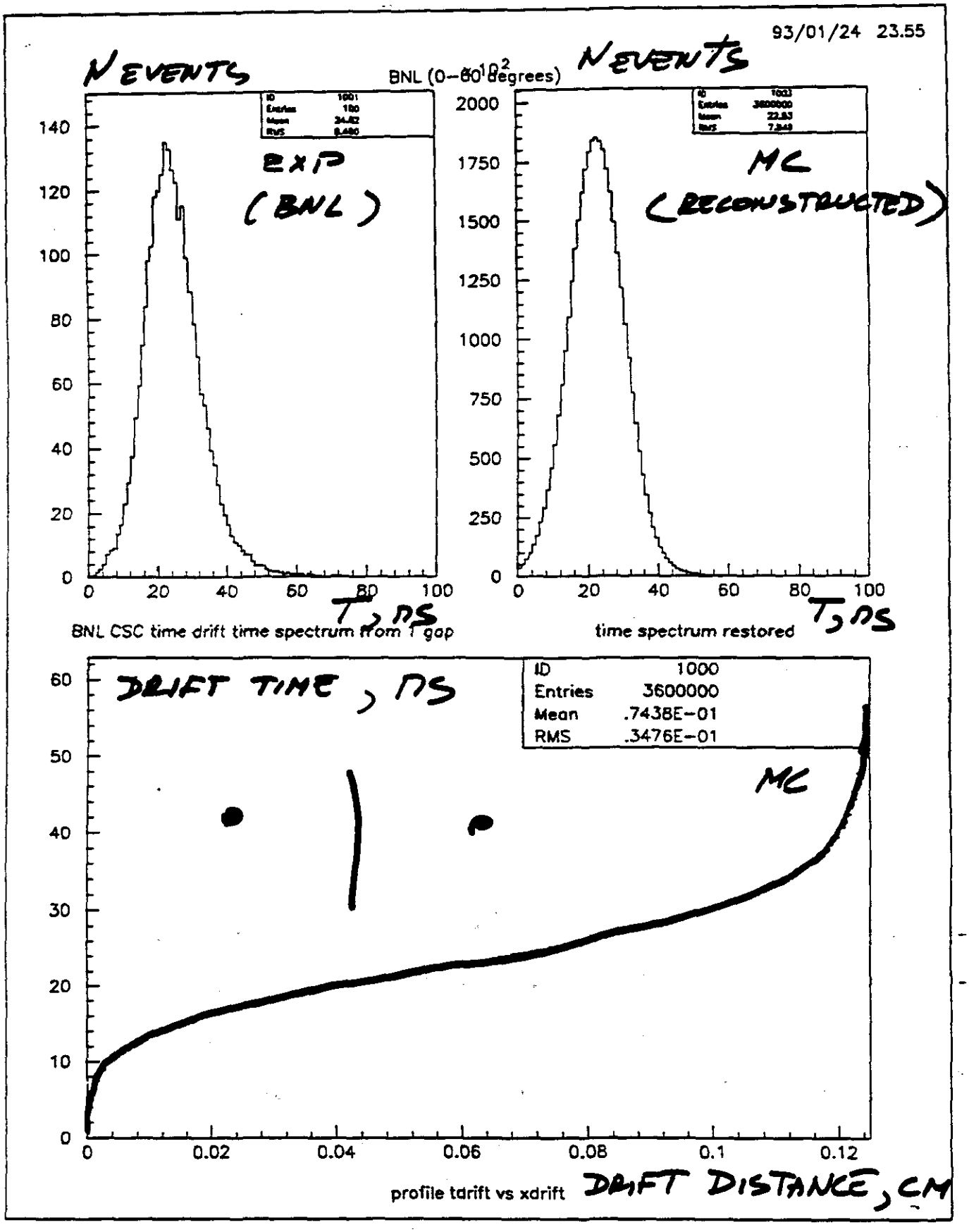
* THERE ARE FIRST EXPERIMENTAL DATA ON CSC timing EFFICIENCY.
DO WE UNDERSTAND THESE data?

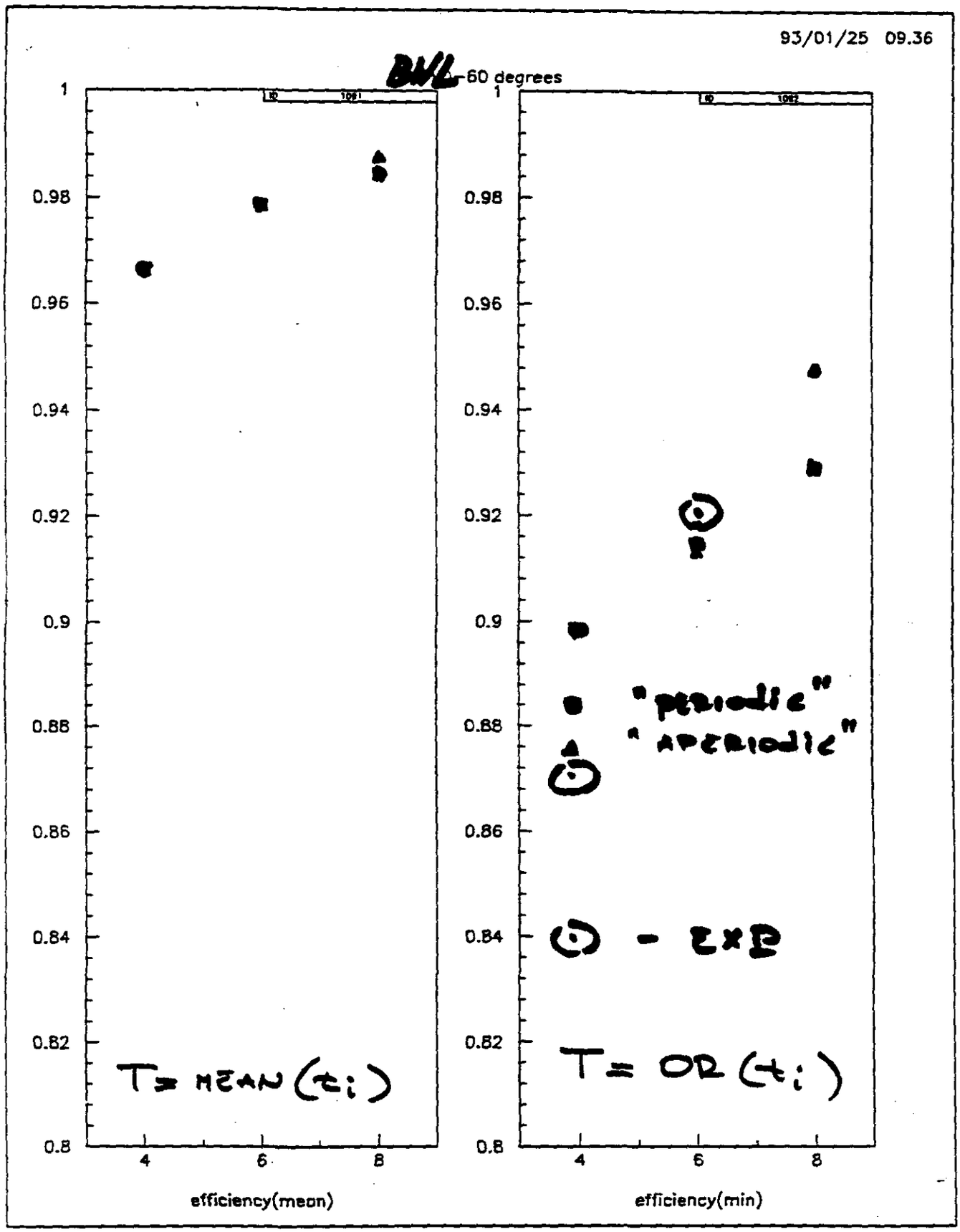


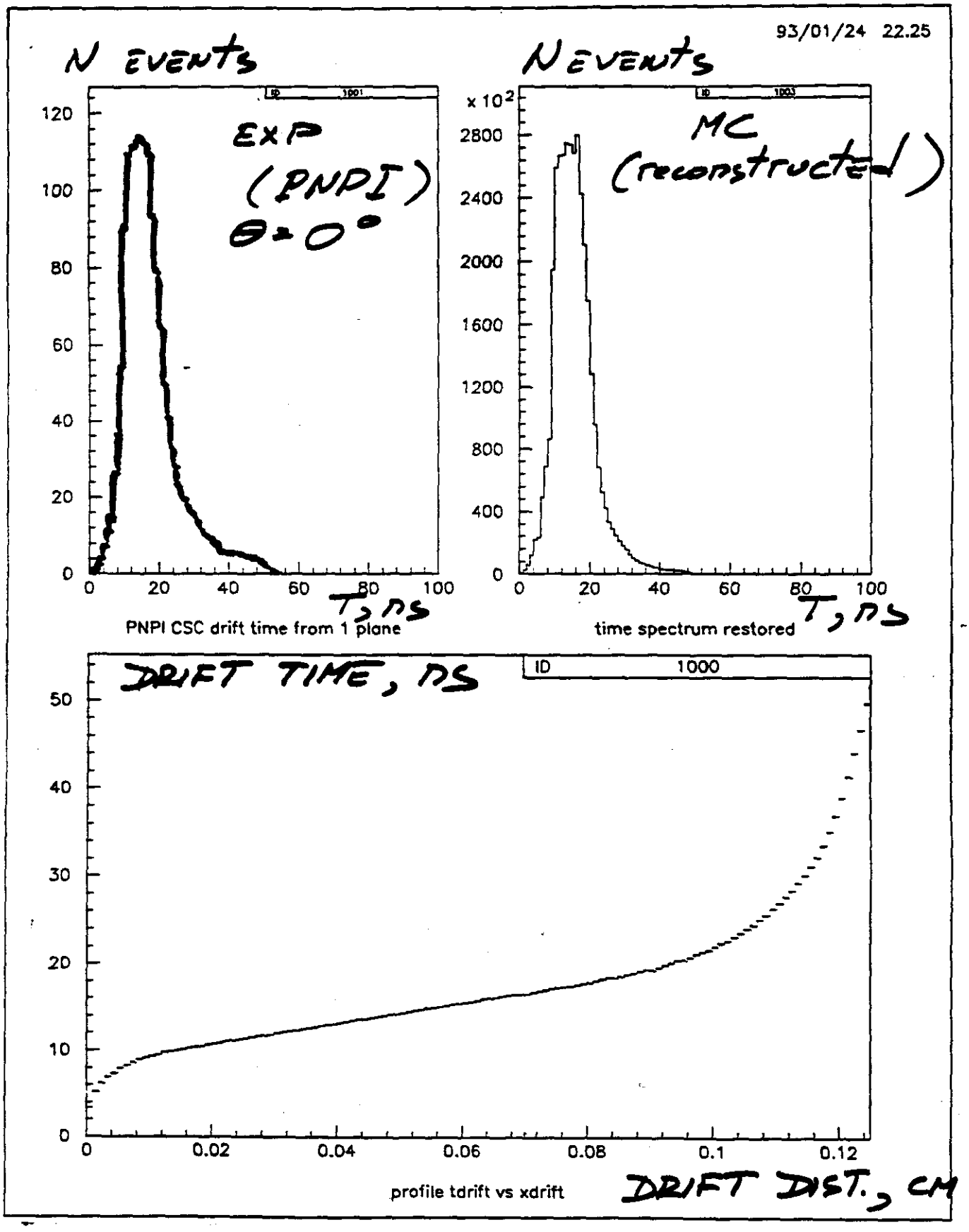
$$\varepsilon = \frac{N(\text{within } 16\,ns)}{N_{TOTAL}}$$

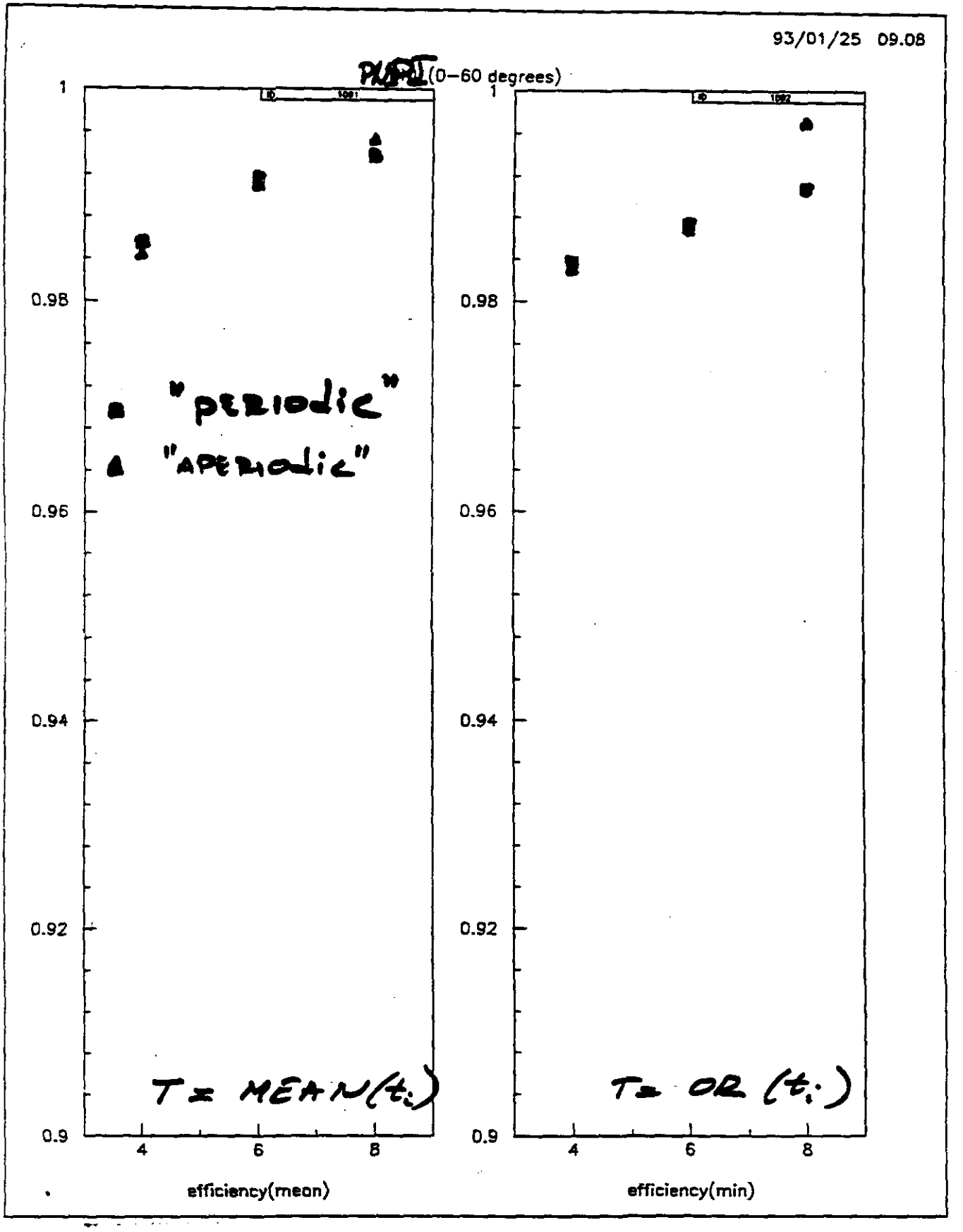
BNL: $\varepsilon = 87\%$ (4 layers)
92% (6 layers)

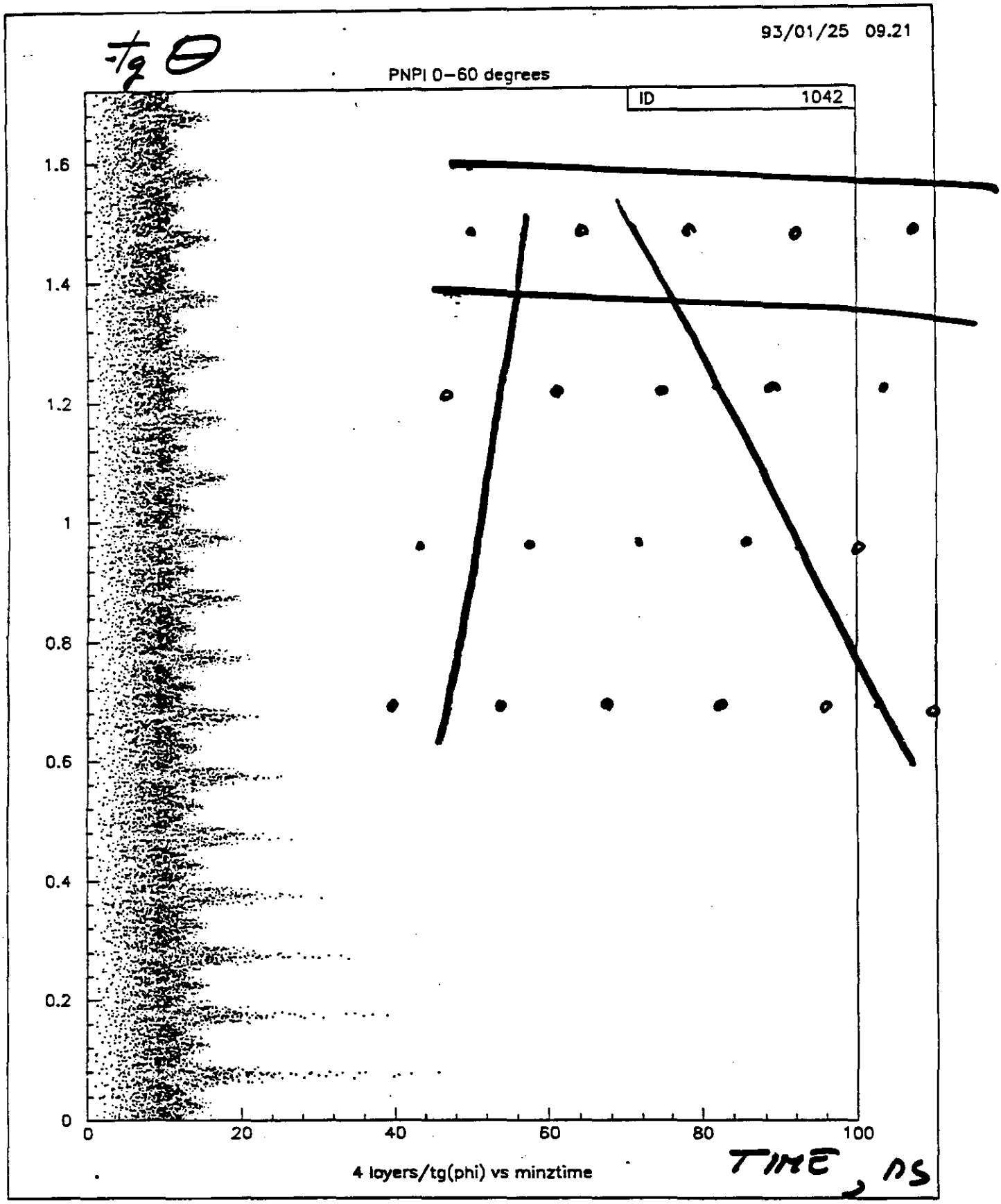
PNPI: $\varepsilon = 98\%$ (4 layers)
$\theta = 0°, 5°, 10°$


93/01/24 23.55
BNL (0--60 degrees)
N EVENTS
EXP
(BNL)
T, ns
BNL CSC time drift time spectrum from 1 gap
N EVENTS
MC
(RECONSTRUCTED)
T, ns
time spectrum restored
DRIFT TIME, ns
ID 1000
Entries 3600000
Mean .7438E-01
RMS .3476E-01
MC
profile tdrift vs xdrift
DRIFT DISTANCE, CM


93/01/25 09.36
DWL-60 degrees
1
0.98
0.96
0.94
0.92
0.9
0.88
0.86
0.84
0.82
0.8
4
6
8
efficiency(mean)
T= MEAN (t_i)
efficiency(min)
T= OR (t_i)
"periodic"
"aperiodic"
- EXP


93/01/24 22.25
N EVENTS
EXP
(PNPI)
θ=0°
PNPI CSC drift time from 1 plane
T, ns
N EVENTS
x 10²
MC
(reconstructed)
time spectrum restored
T, ns
DRIFT TIME, ns
ID 1000
profile tdrift vs xdrift
DRIFT DIST., cm

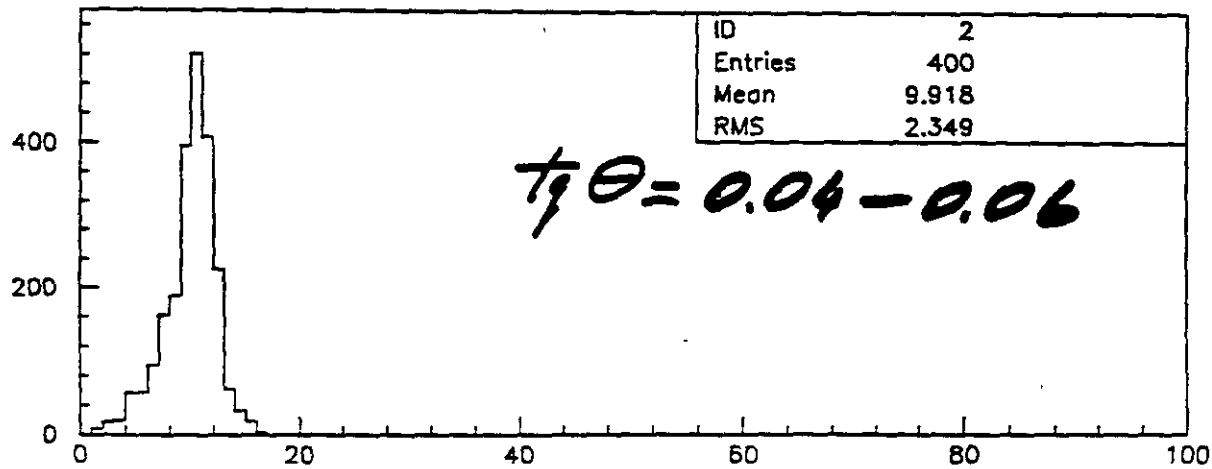

93/01/25 09.08
PLOT (0–60 degrees)
1
0.98
0.96
0.94
0.92
0.9
4
6
8
efficiency(mean)
efficiency(min)
"PERIODIC"
"APERIODIC"
T = MEAN(t_i)
T = OR(t_i)

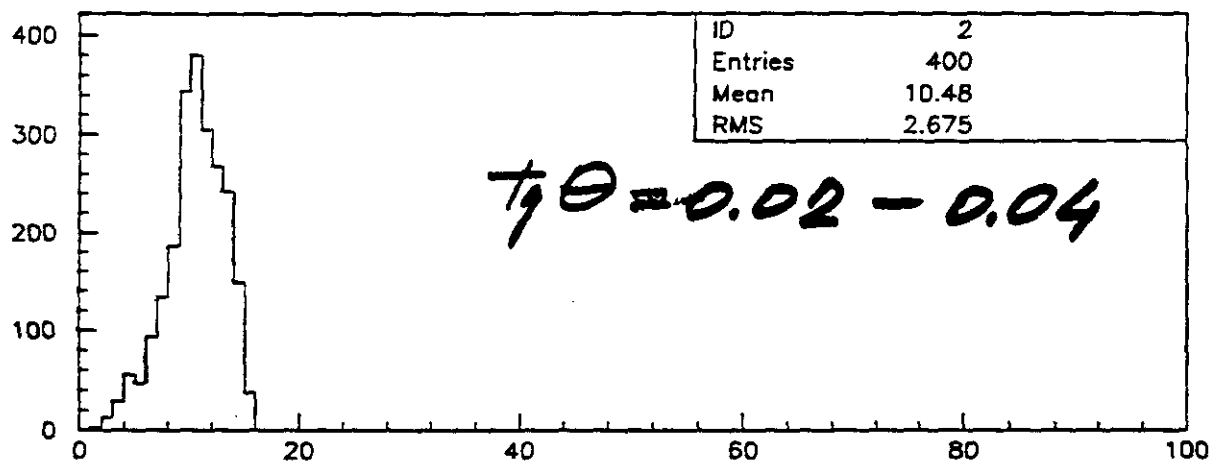


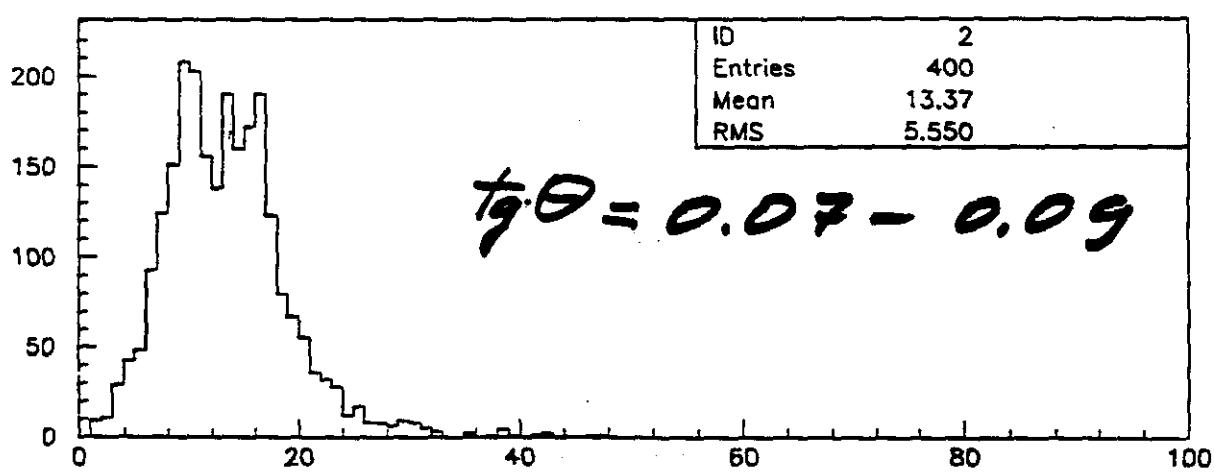
OR (t_i)

4 LAYERS.

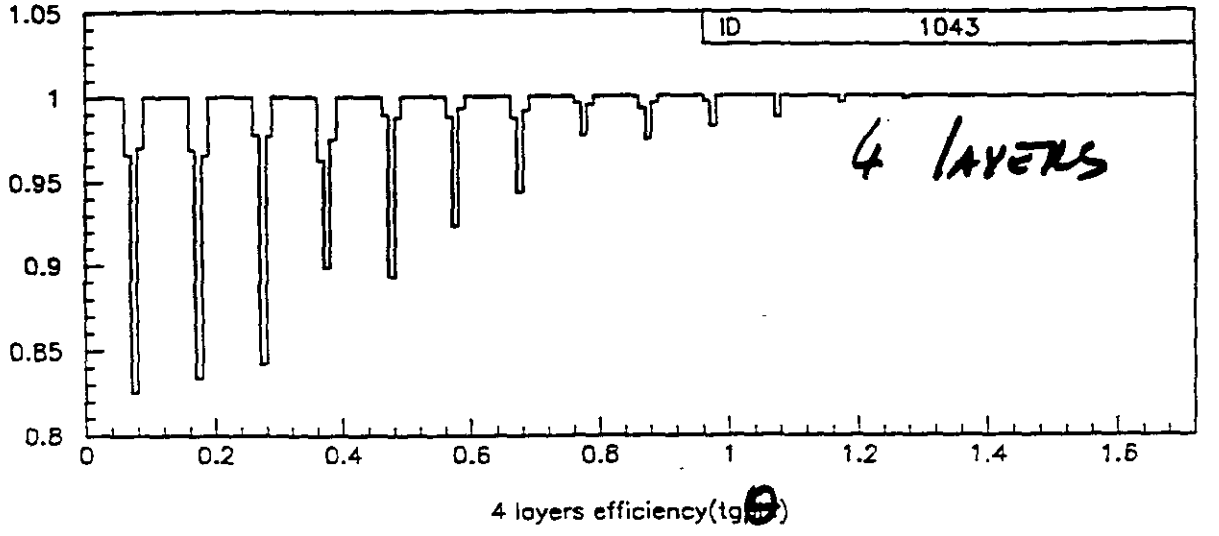
93/01/24 23.00

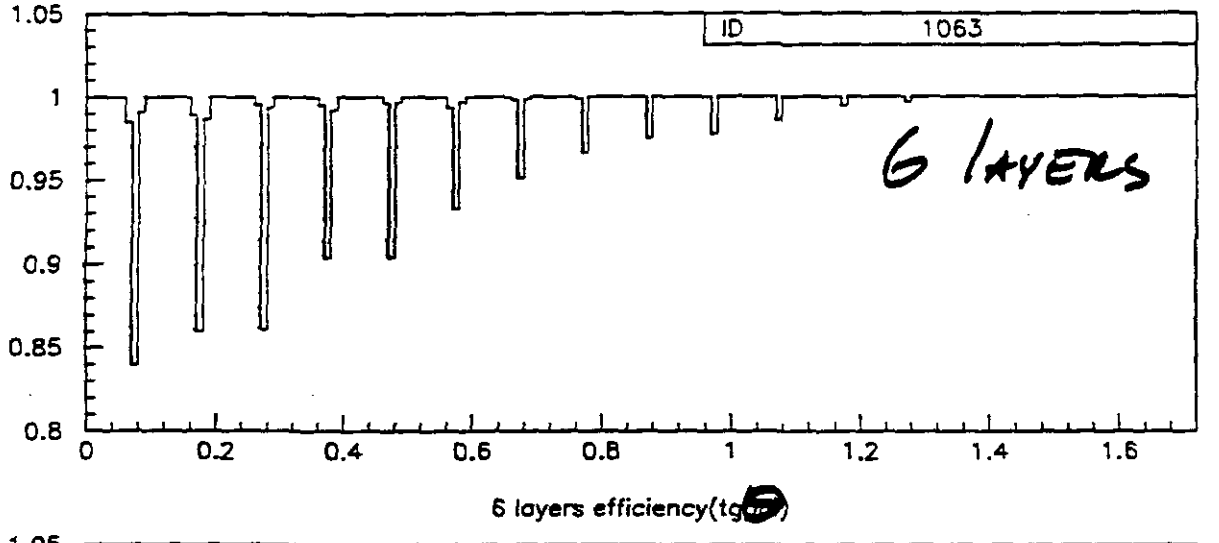

ID 2
Entries 400
Mean 9.918
RMS 2.349
tg θ = 0.04 – 0.06
4 layers/tg(phi) vs minztime

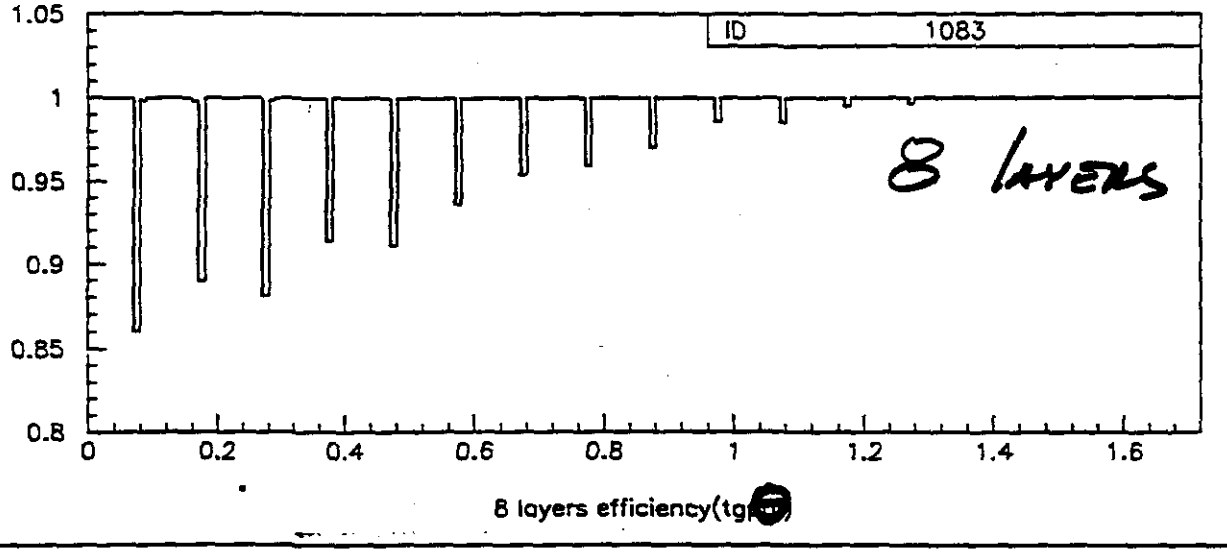

ID 2
Entries 400
Mean 10.48
RMS 2.675
tg θ = 0.02 – 0.04
4 layers/tg(phi) vs minztime

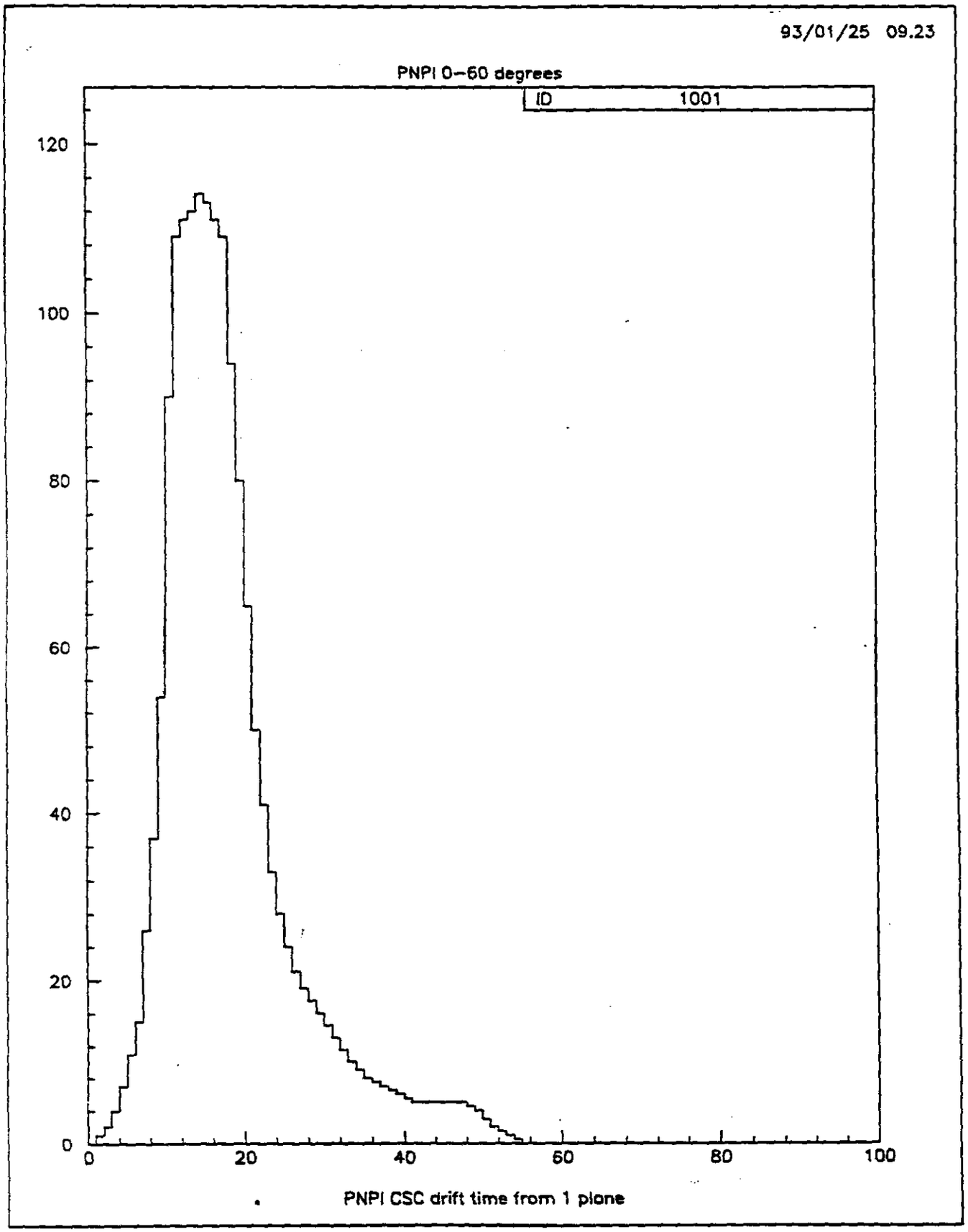

ID 2
Entries 400
Mean 13.37
RMS 5.550
tg θ = 0.07 – 0.09
4 layers/tg(phi) vs minztime
T, ns

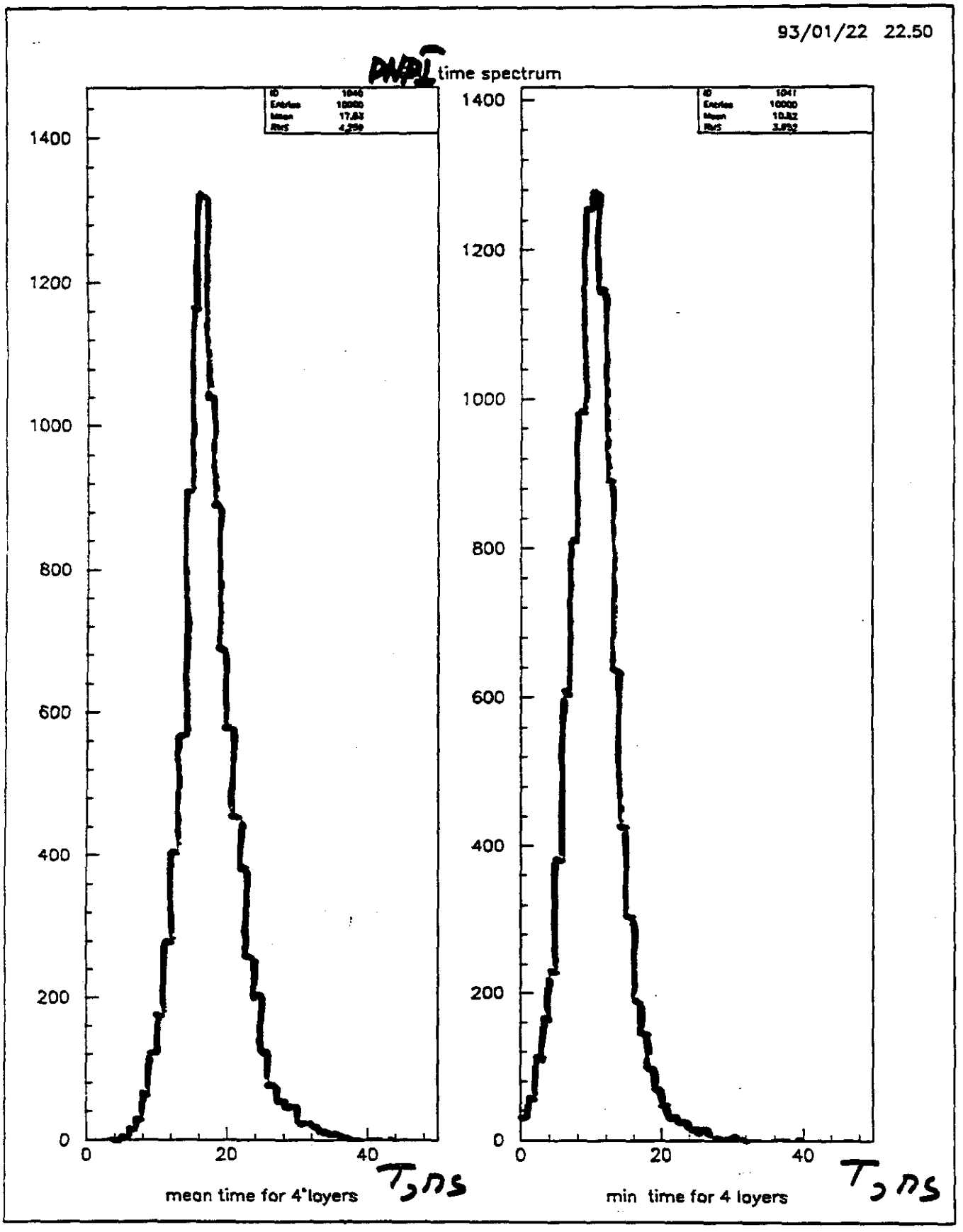
93/01/25 09.19

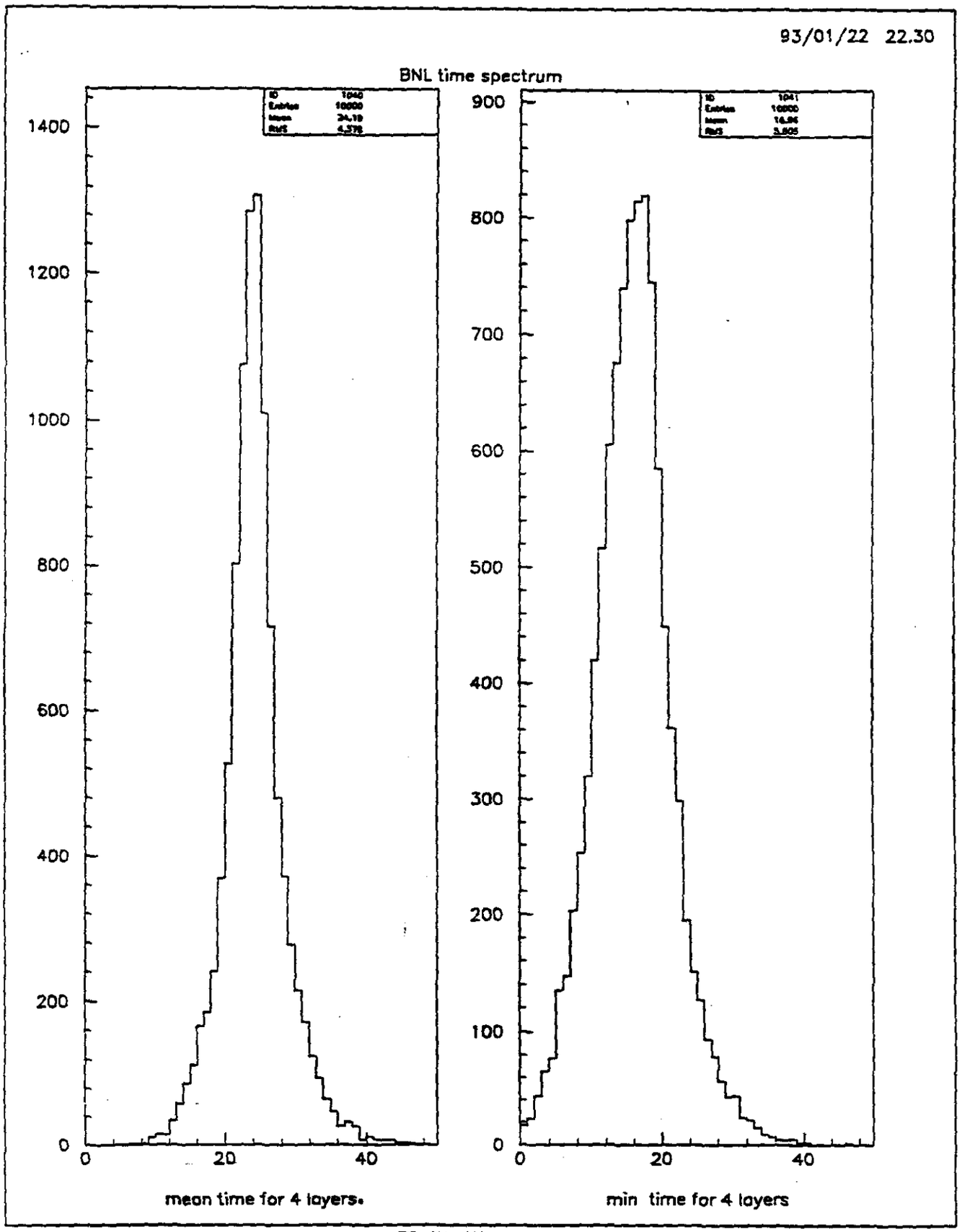

ID 1043
4 LAYERS
1.05
1
0.95
0.9
0.85
0.8
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
4 layers efficiency(tg

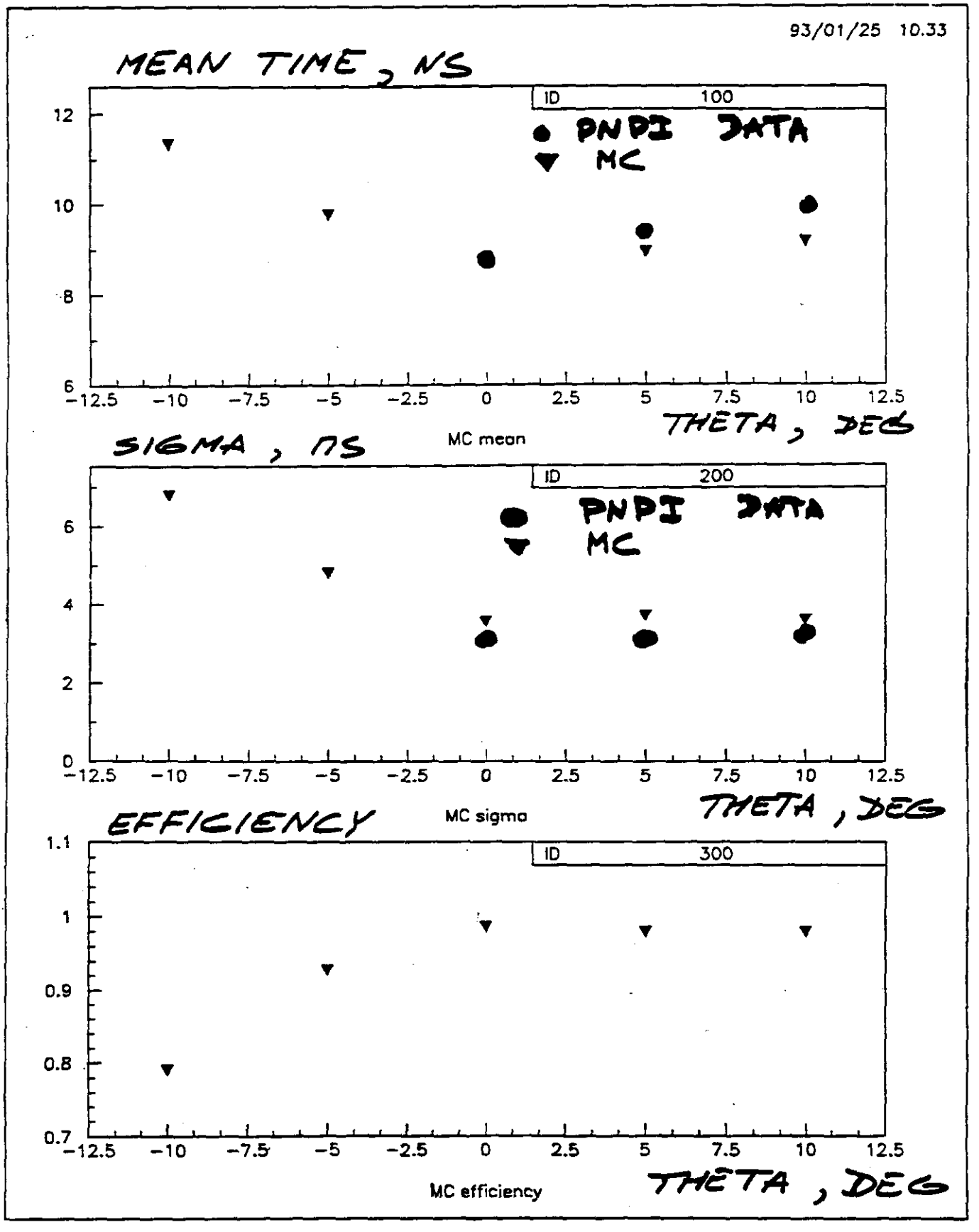

ID 1063
6 LAYERS
1.05
1
0.95
0.9
0.85
0.8
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
6 layers efficiency(tg


ID 1083
8 LAYERS
1.05
1
0.95
0.9
0.85
0.8
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
8 layers efficiency(tg


93/01/25 09.23
PNPI 0–60 degrees
ID 1001
120
100
80
60
40
20
0
0
20
40
60
80
100
PNPI CSC drift time from 1 plane


93/01/22 22.50
time spectrum
1400
1200
1000
800
600
400
200
0
0
20
40
mean time for 4 layers
min time for 4 layers


93/01/22 22.30
BNL time spectrum
1400
1200
1000
800
600
400
200
0
0
20
40
mean time for 4 layers.
900
800
700
600
500
400
300
200
100
0
0
20
40
min time for 4 layers


93/01/25 10.33
MEAN TIME, NS
ID 100
PNPI DATA
MC
THETA, DEG
MC mean
SIGMA, NS
ID 200
PNPI DATA
MC
THETA, DEG
MC sigma
EFFICIENCY
ID 300
THETA, DEG
MC efficiency

Conclusions

* USING LOW THRESHOLD ELECTRONICS FOR ANODE READOUT IT IS POSSIBLE TO REACH $\varepsilon > 98\%$ IN BARREL REGION EVEN FOR 4 LAYERS [WITH OR]
* PROBABLY STAGGERING IS NOT NECESSARY (IMPROVEMENT IS NOT VERY LARGE, BUT OPTIMIZATION — NON-TRIVIAL)
* THERE IS NO ESSENCIAL DIFFERENCE IN TIMING EFFICIENCY BETWEEN 2 TYPES OF CHAMBER GEOMETRY CONSIDERED, BUT "APERIODIC" STRUCTURE IS slightly BETTER
* THERE IS REASONABLE AGREEMENT BETWEEN EXPERIMENTAL DATA AND Monte Carlo results

gem

γeμ

Presentation by:

Alexei Vorobyov

New results on CSCs from Gatchina

A. VOROBYOV

I.

PNPI PROTOTYPE OF CSC

4 layers

380 × 440 mm² - sensitive area

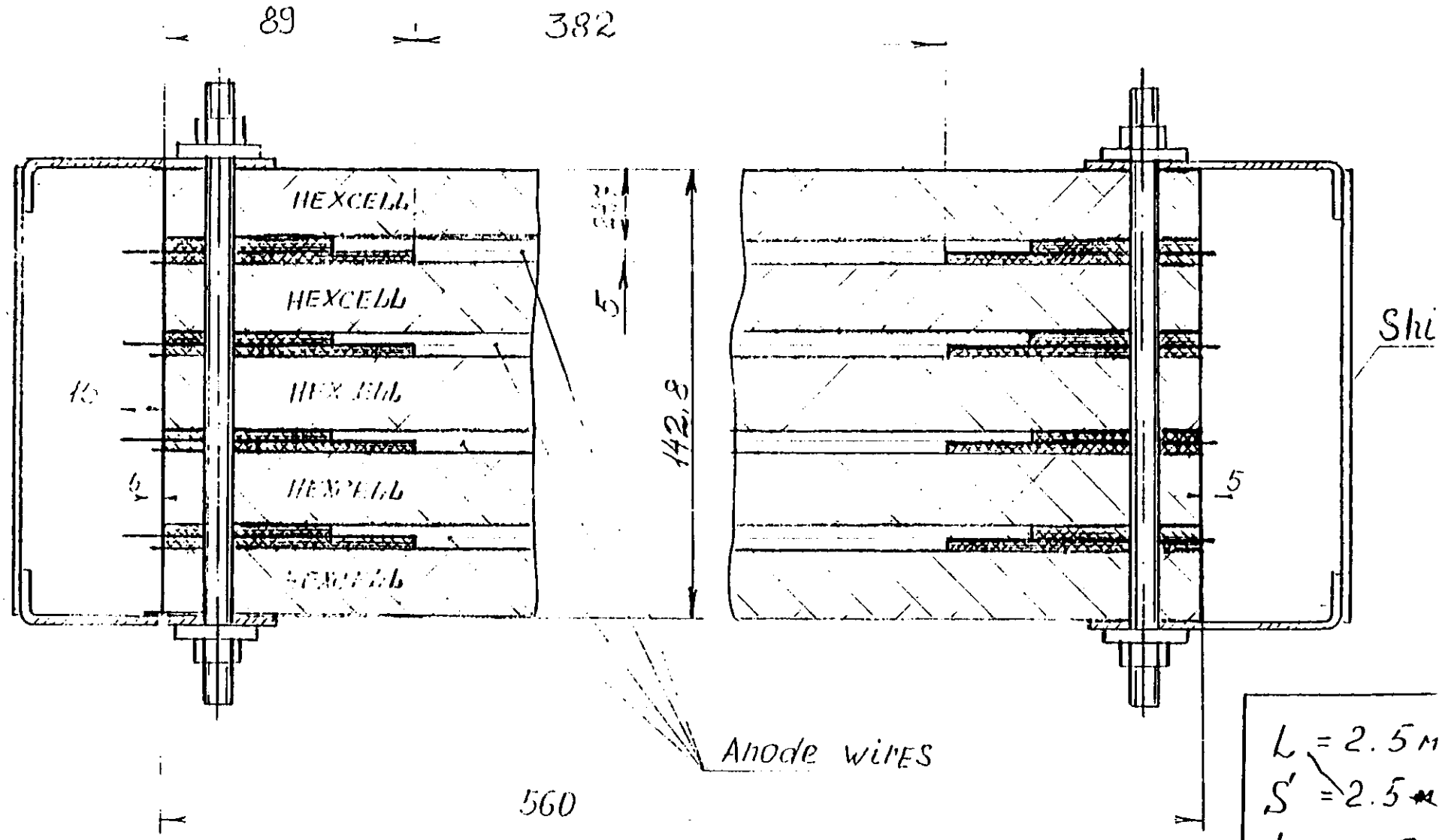
5 mm gap.

2.5 mm dist. between wires

25 μm wire diam.

CSC - 380×440

CROSS SECTION
(ALONG THE WIRES)
(A-A)



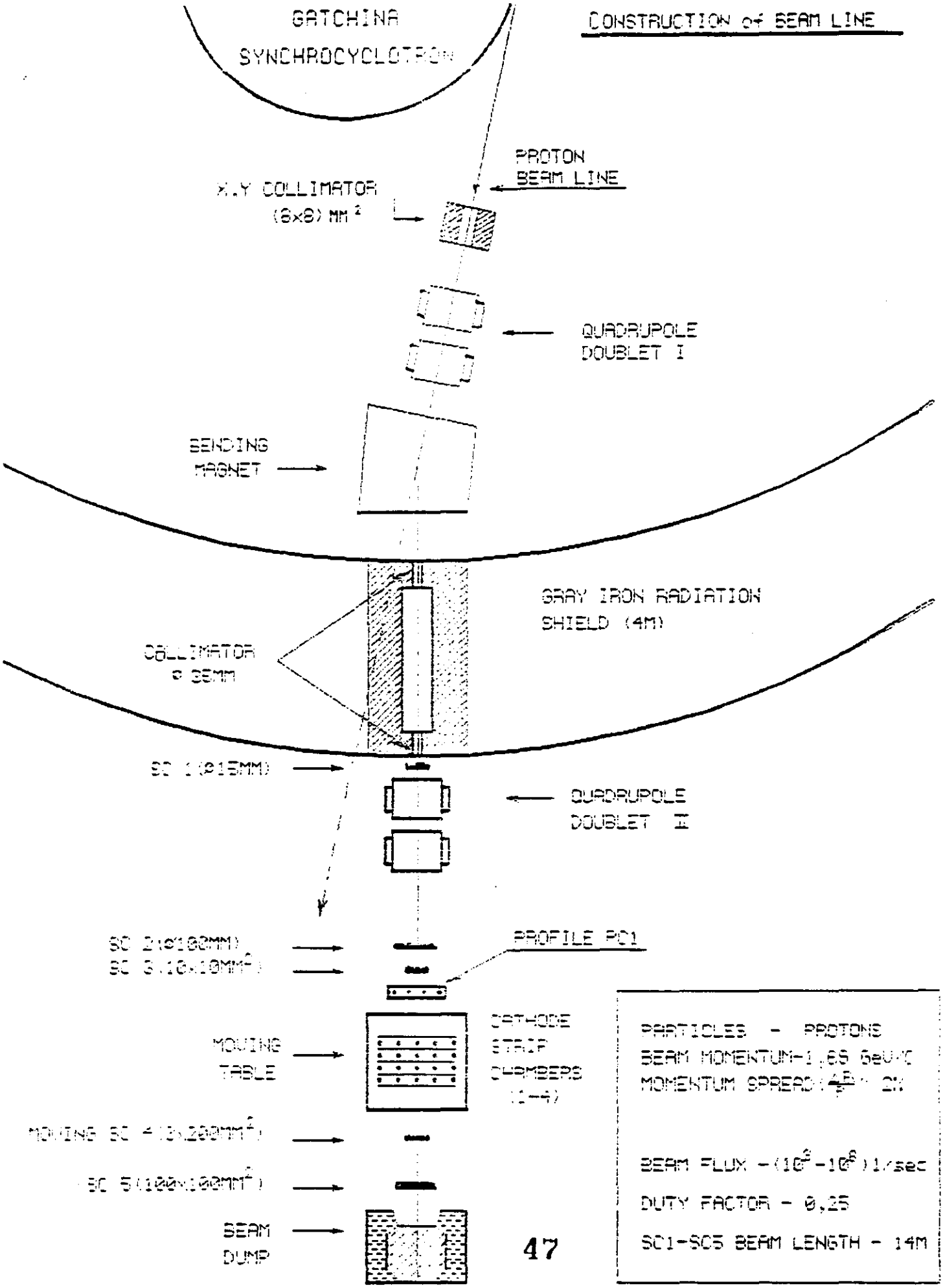
$L = 2.5$ m
$S' = 2.5$
$d_s = 25\mu$

Fig. 2

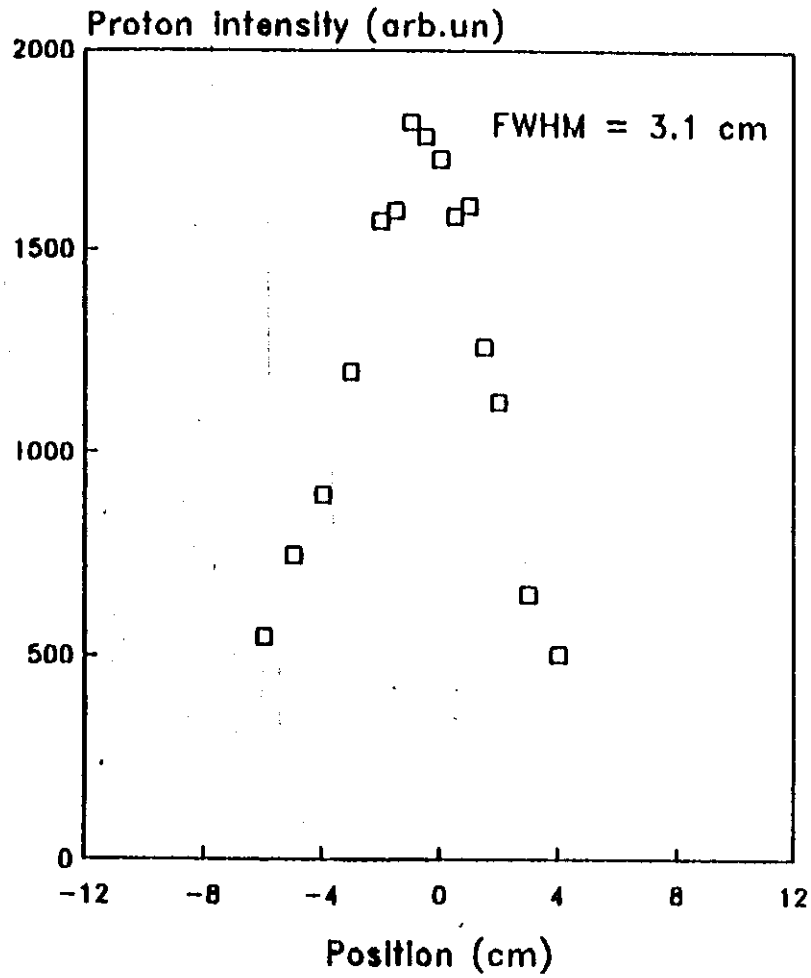
45

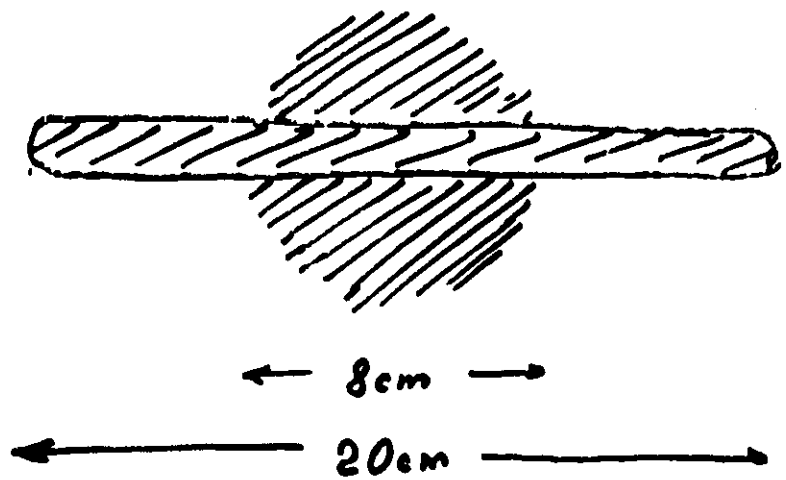
II.

1.7 GeV/c PROTON TEST BEAM


GATCHINA
SYNCHROCYCLOTRON
CONSTRUCTION of BEAM LINE
PROTON
BEAM LINE
X,Y COLLIMATOR
(8x8) MM²
QUADRUPOLE
DOUBLET I
BENDING
MAGNET
GRAY IRON RADIATION
SHIELD (4M)
COLLIMATOR
Φ 35MM
SC 1(Φ15MM)
QUADRUPOLE
DOUBLET II
SC 2(Φ100MM)
SC 3(10x10MM²)
PROFILE PC1
MOVING
TABLE
CATHODE
STRIP
CHAMBERS
(1-4)
MOVING SC 4(10x200MM²)
SC 5(100x100MM²)
BEAM
DUMP
PARTICLES - PROTONS
BEAM MOMENTUM-1,65 GeV/C
MOMENTUM SPREAD(Δp/p) 2%
BEAM FLUX -(10⁵-10⁶)1/sec
DUTY FACTOR - 0,25
SC1-SC5 BEAM LENGTH - 14M

Beam profile





1.7 GeV/c protons

$I_p \geq 10^3\ s^{-1}$

Duty factor = 30%

III

CSC's TESTS IN PROTON BEAM

$2 \cdot 10^6$ events on tapes.

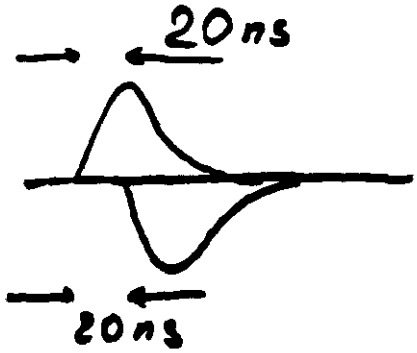
* Efficiency
* time resolution
* space resolution
* angular dependence
  $\varphi = 0°, 5°, 10°$
  $\theta = 0°, 10°, 20°, 30°$
* various strip configurations
  floating strips $w = 5$ mm, 7 mm
  wide strips $w = 5$ mm, 7 mm

Area TDC_1

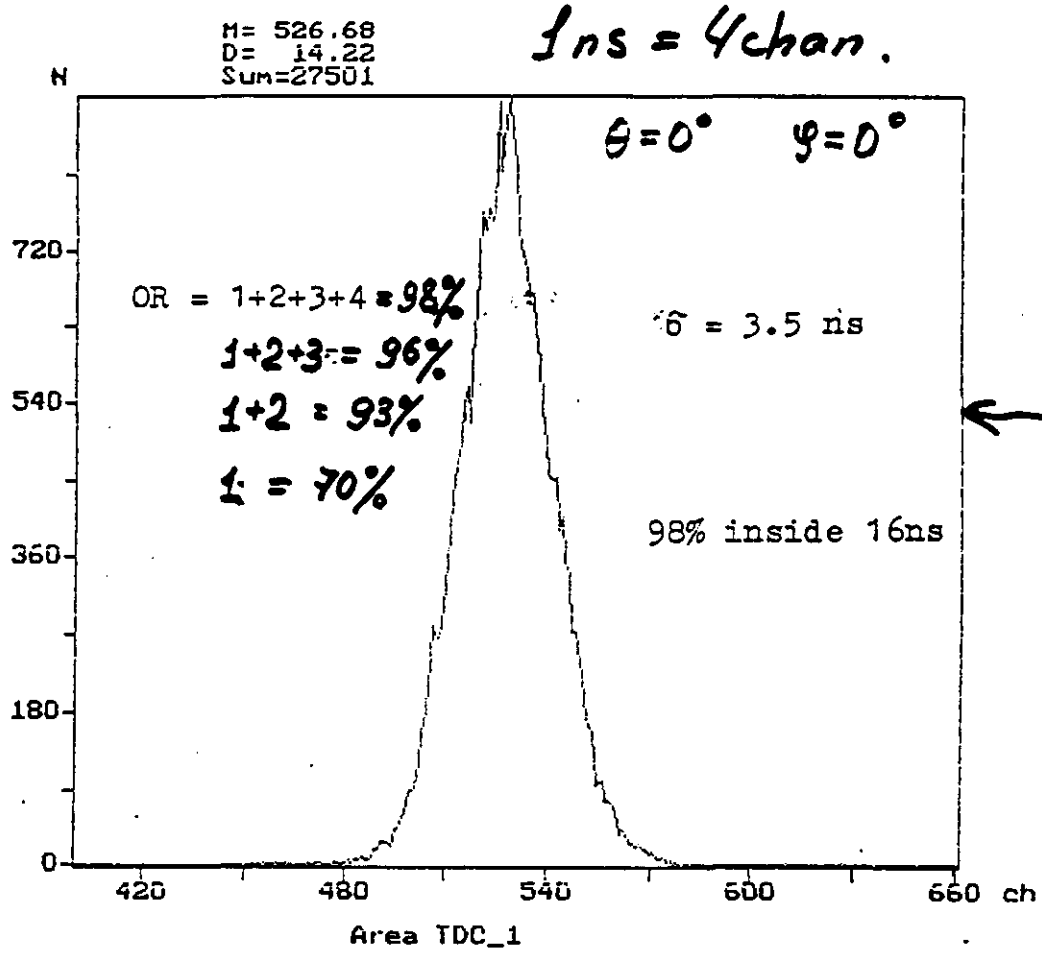
III a Efficiency

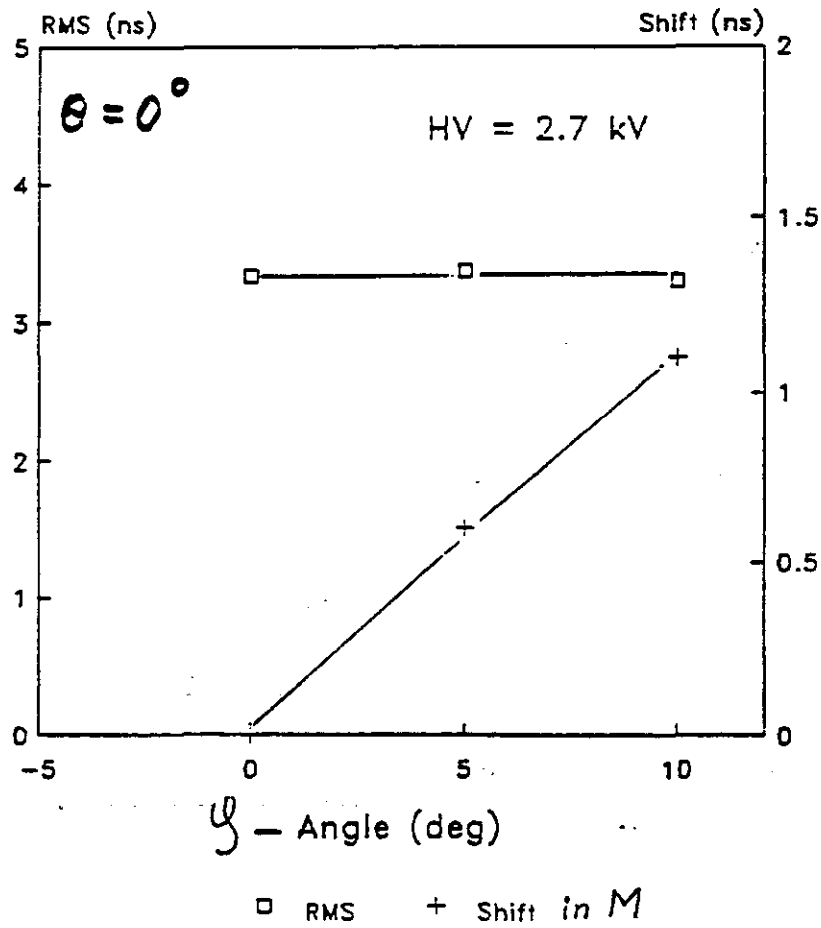
III b. TIME RESOLUTION

Zero-crossing method.

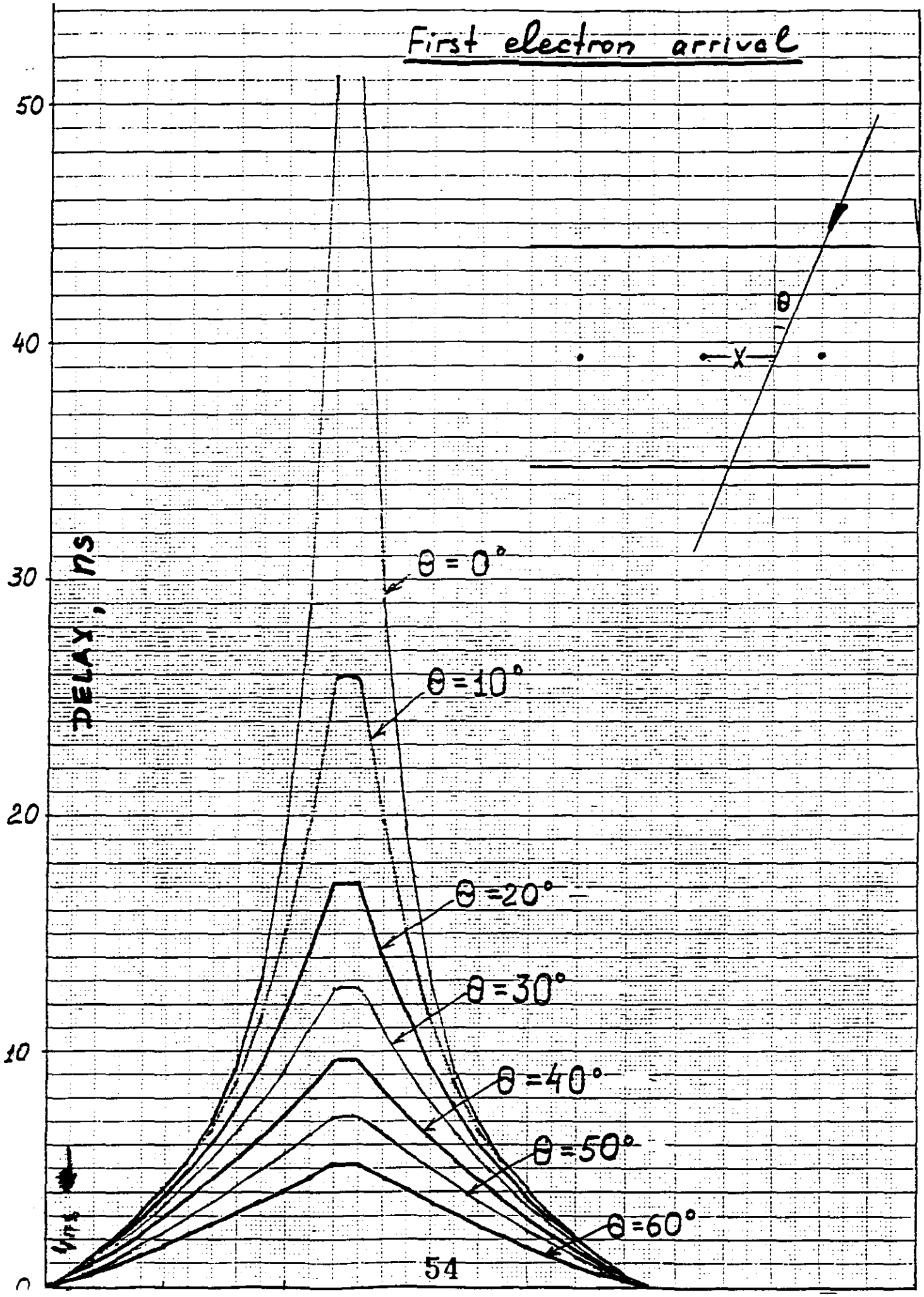


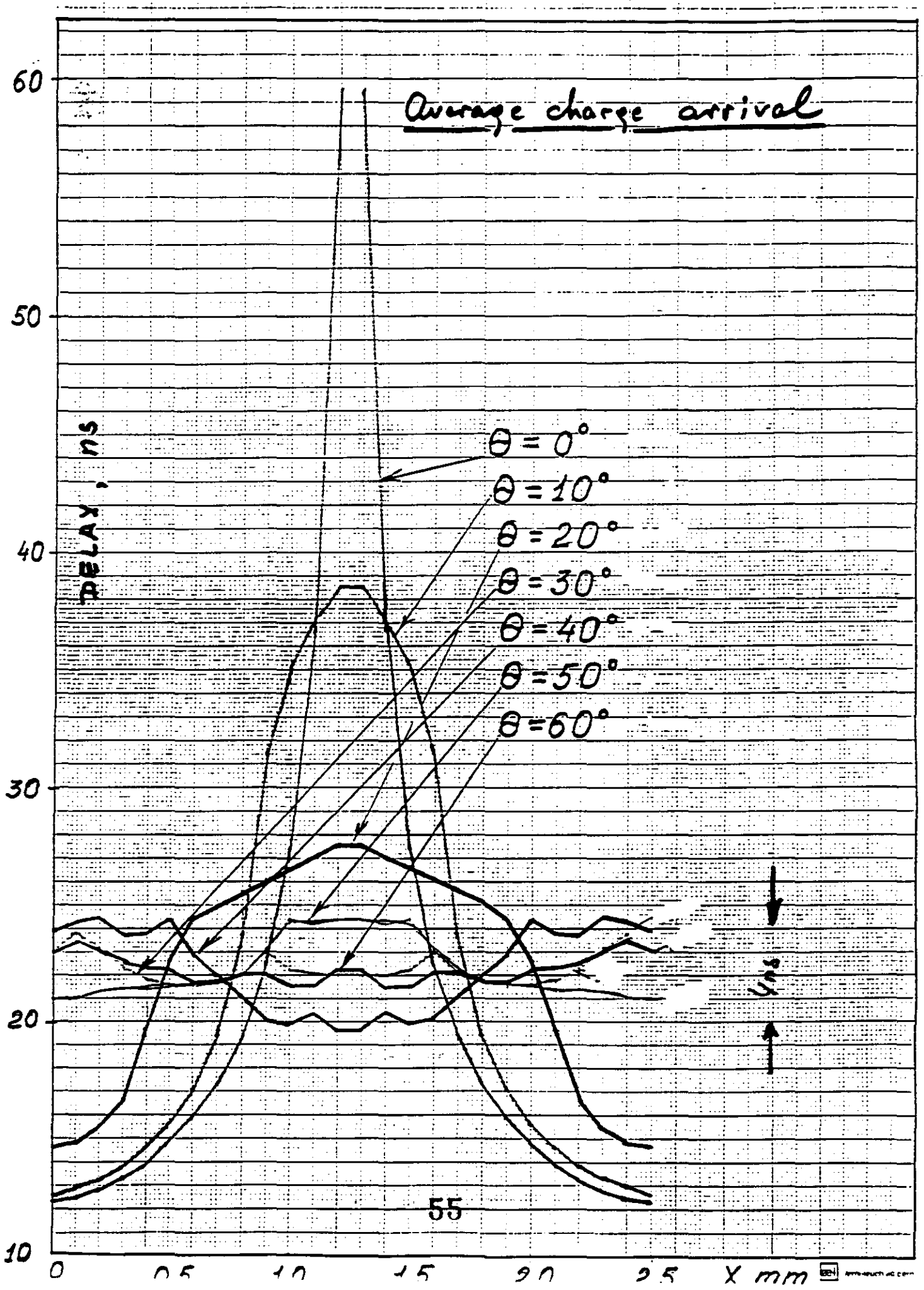
Approximately, this method measures the arrival of the average charge.

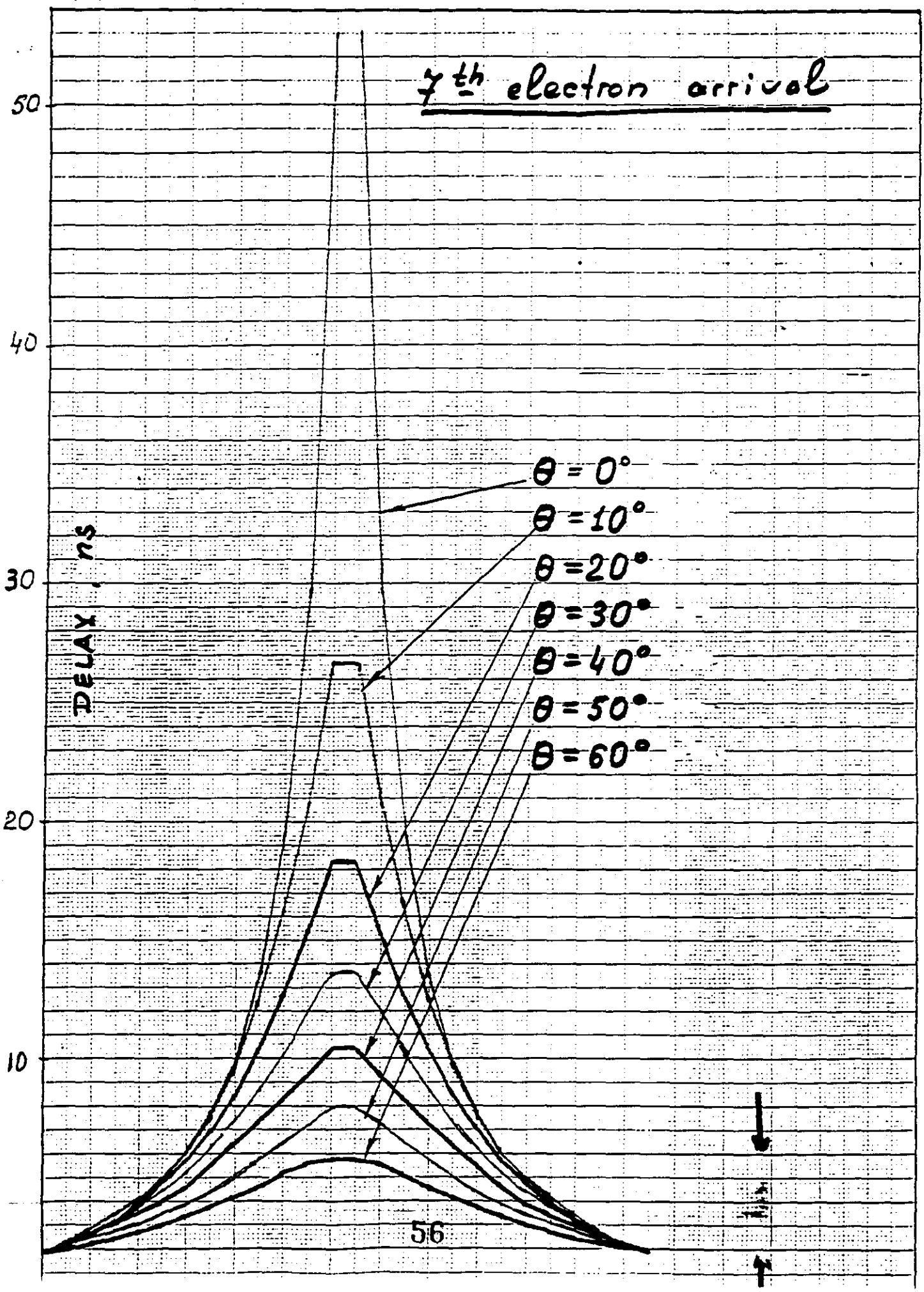




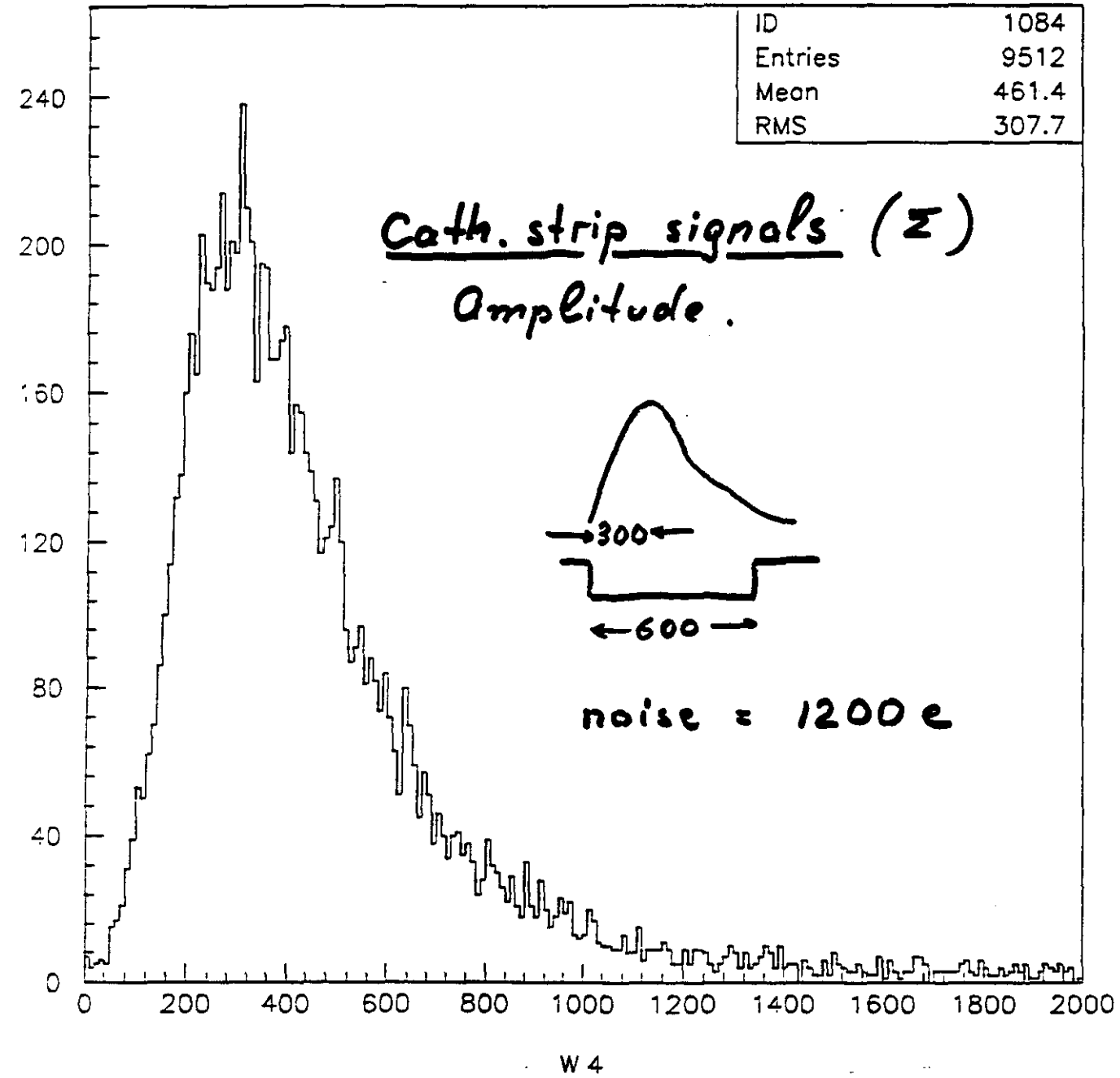
HV = 2.7 kV
σ = 3.5 ns


First electron arrival
50
40
30
20
10
0
DELAY, ns
θ = 0°
θ = 10°
θ = 20°
θ = 30°
θ = 40°
θ = 50°
θ = 60°
θ
X


Average charge arrival
θ = 0°
θ = 10°
θ = 20°
θ = 30°
θ = 40°
θ = 50°
θ = 60°
DELAY, ns
4 ns
60
50
40
30
20
10
0
0.5
1.0
1.5
2.0
2.5
X mm

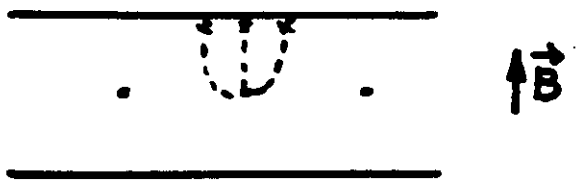

7th electron arrival
50
40
30
20
10
DELAY, ns
θ = 0°
θ = 10°
θ = 20°
θ = 30°
θ = 40°
θ = 50°
θ = 60°

Analysis of the cathode signals is just started



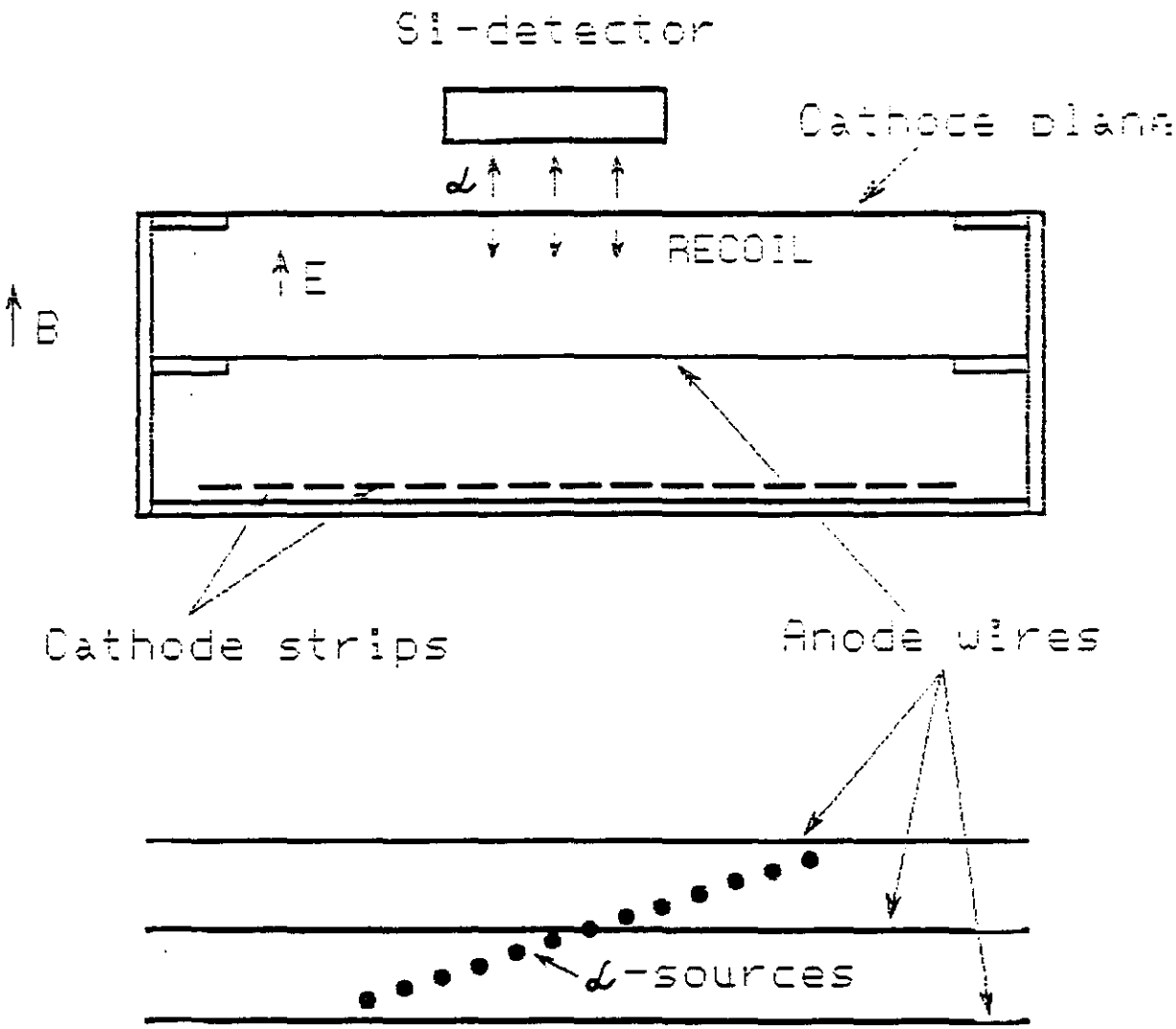
IV.

CSCs in End Caps
magnetic field



shift along s-wires.
resolution!

Schematic of experimental set-up



Chamber: L=2,3mm

S=2,5mm

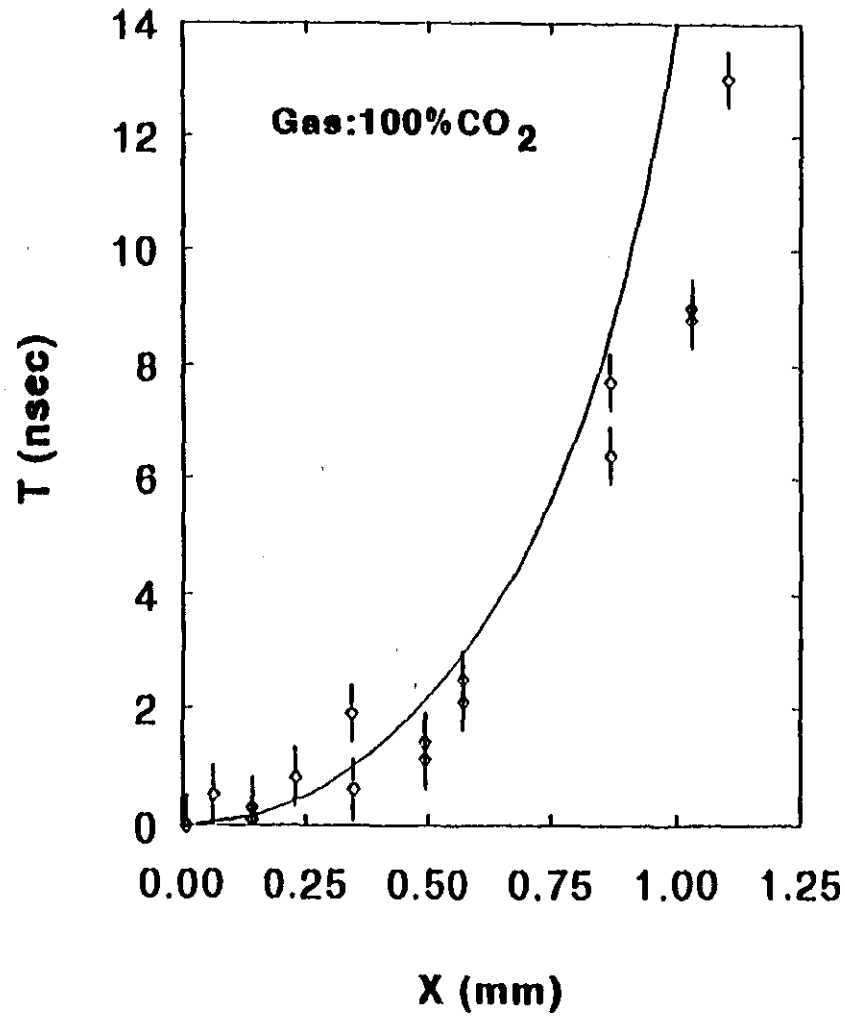
d_s=25μm

cathode strip pitch-2mm

α-source- ^{209}Po

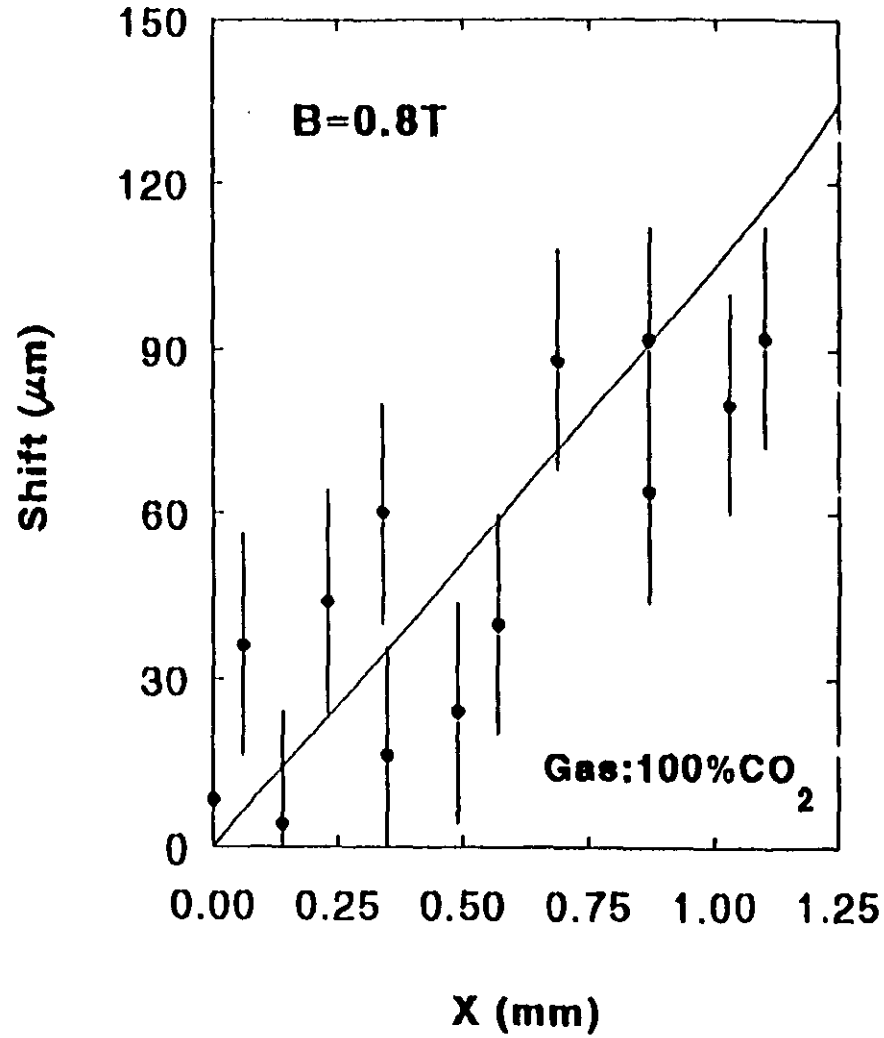
hole diameter-0,6mm

Time shift
verses the position place



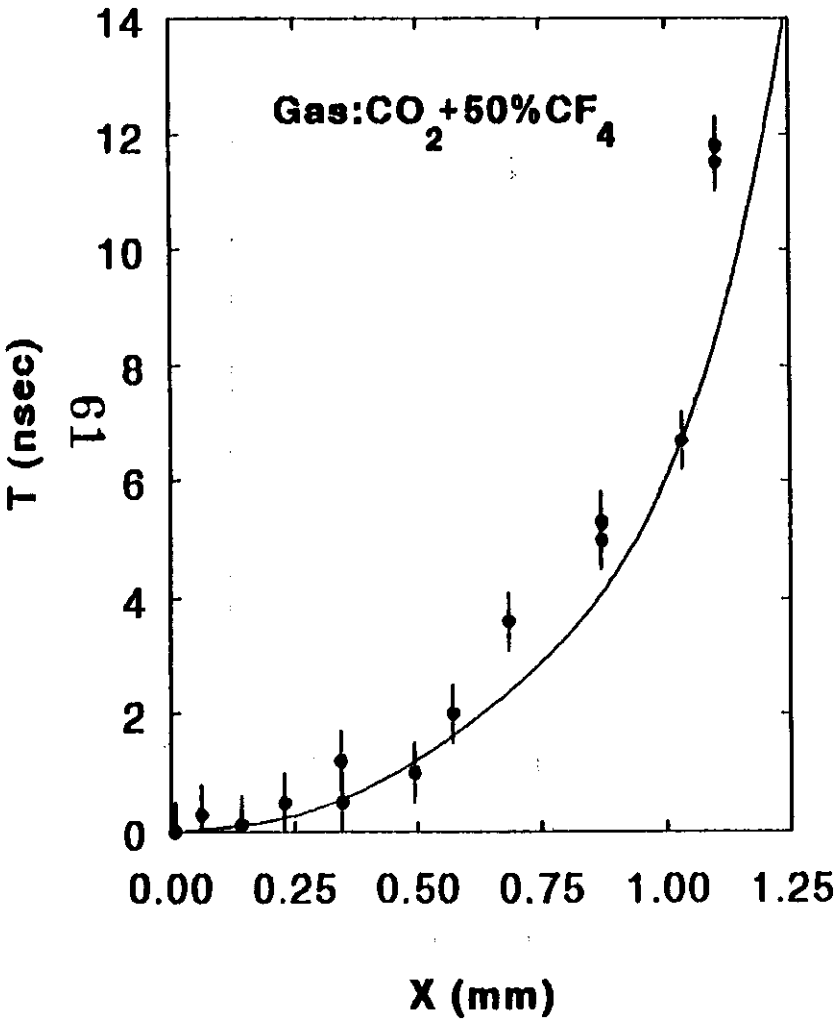
◇ PNPI measurements
— Blagl program

Coordinate shift verses
the source place in magnetic field



• PNPI measurements
— Calculations

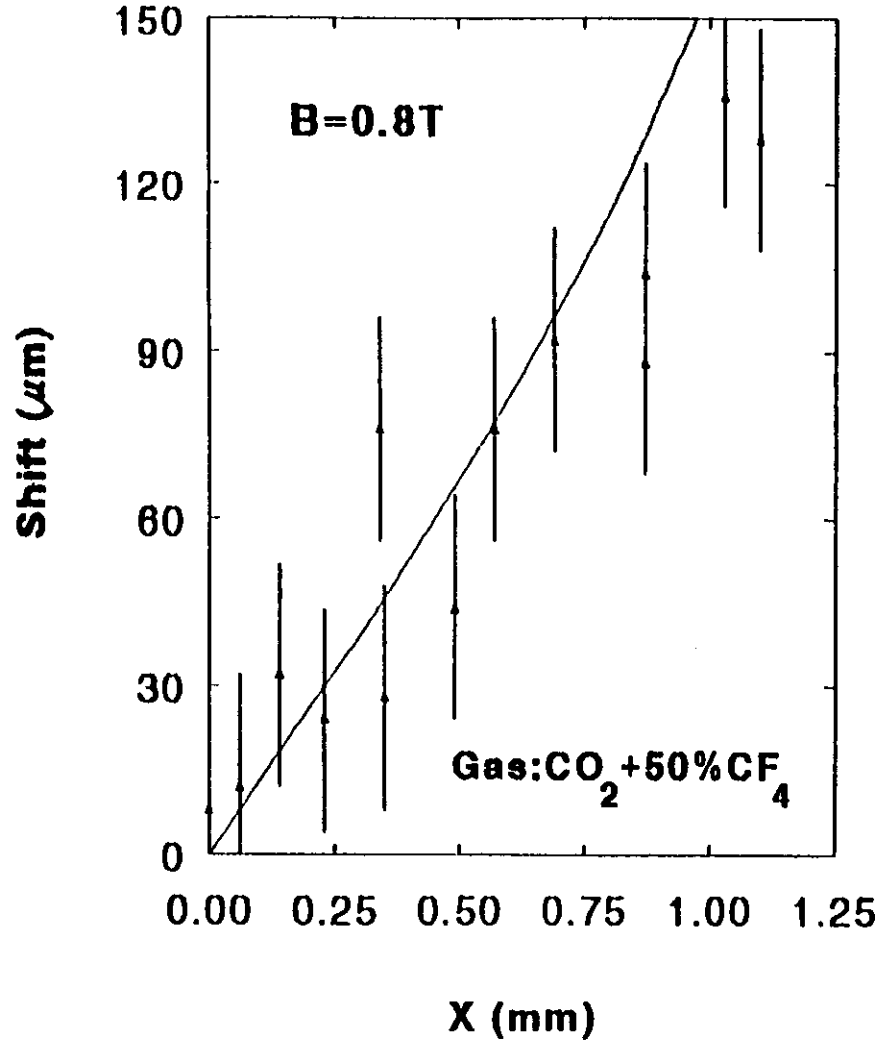
Time shift
verses the position place



● PNPI measurements

—— Biagi program

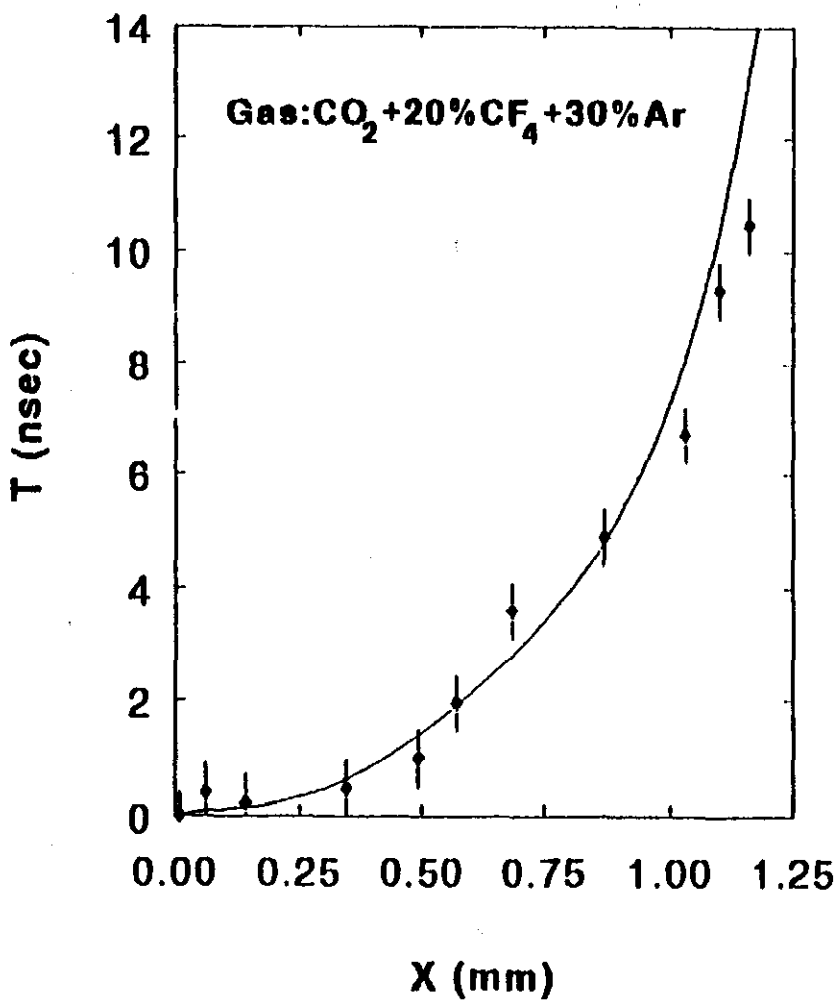
Coordinate shift verses
the source place in magnetic field



▲ PNPI measurements

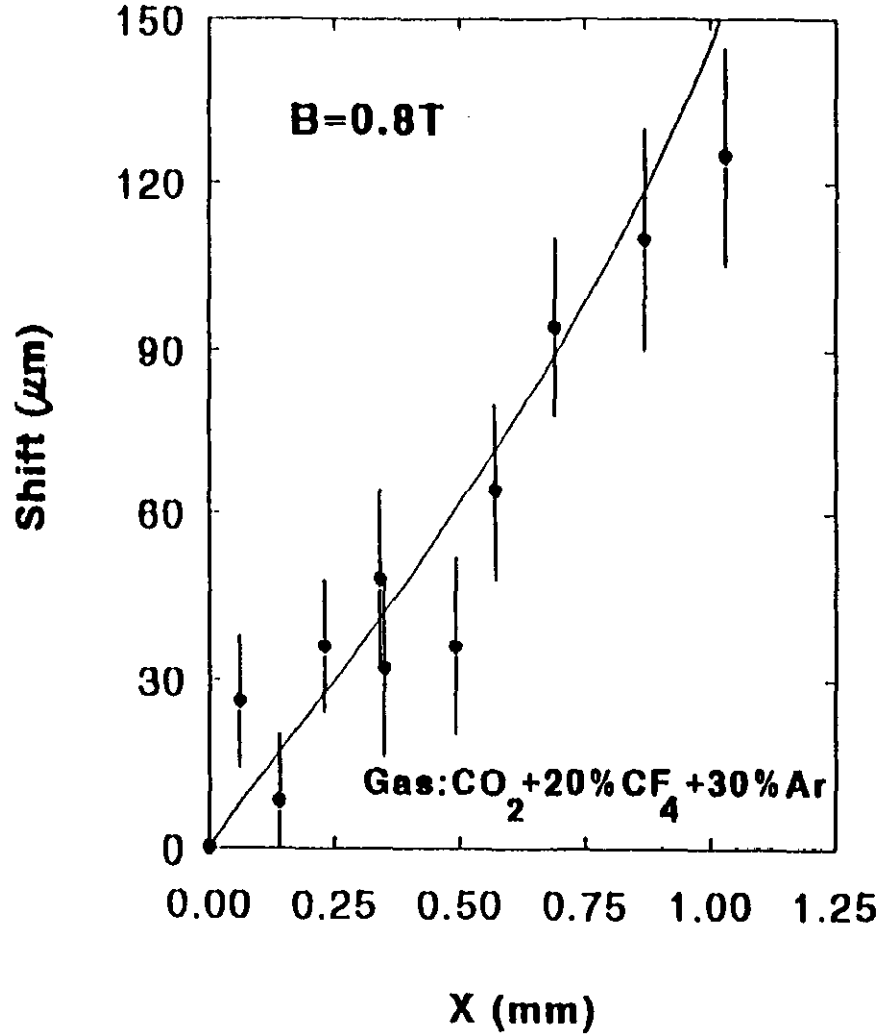
—— Calculations

Time shift
verses the position place



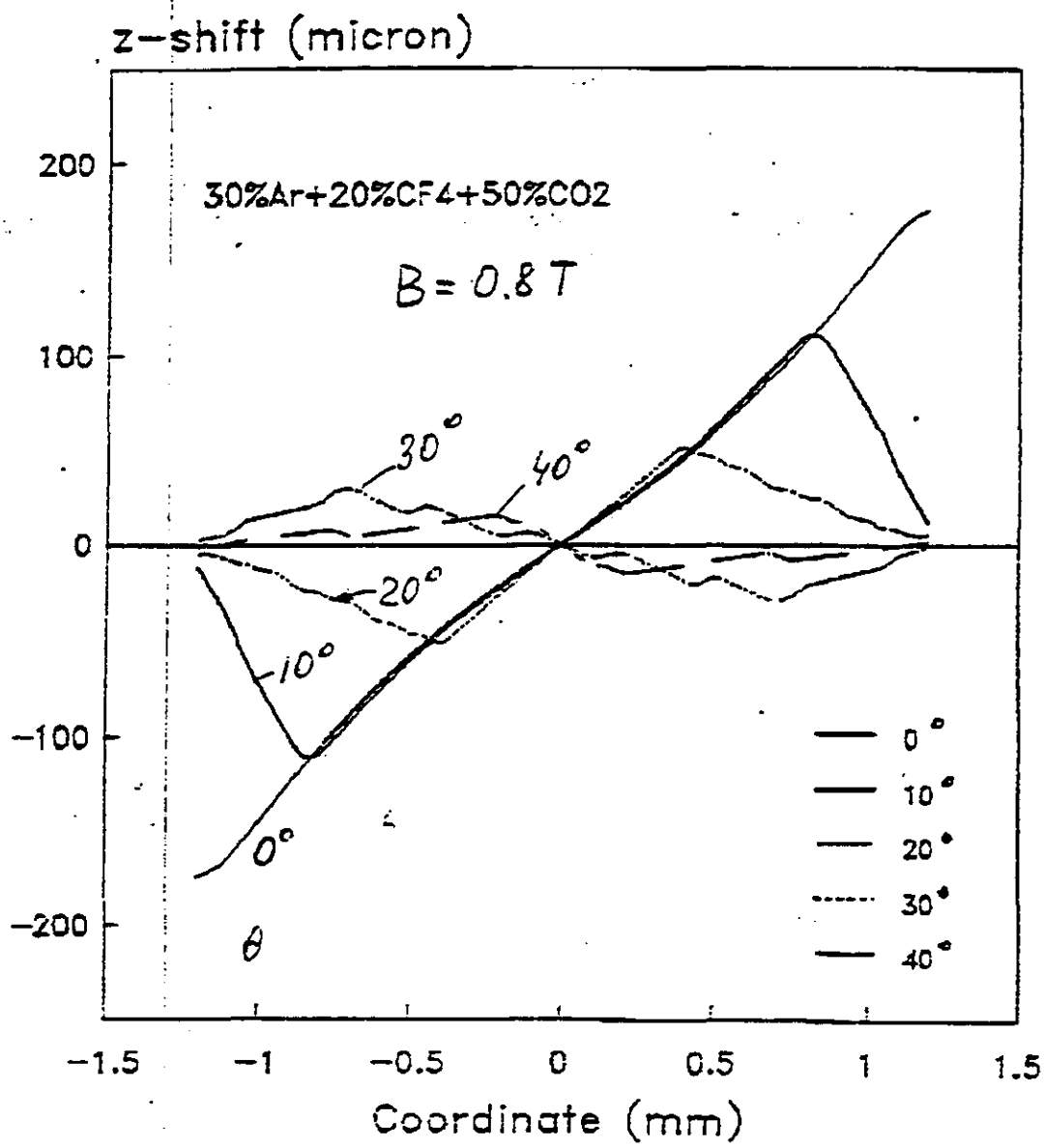
◆ PNPI measurements
— Blagl program

Coordinate shift verses
the source place in magnetic field



● PNPI measurements
— Calculations

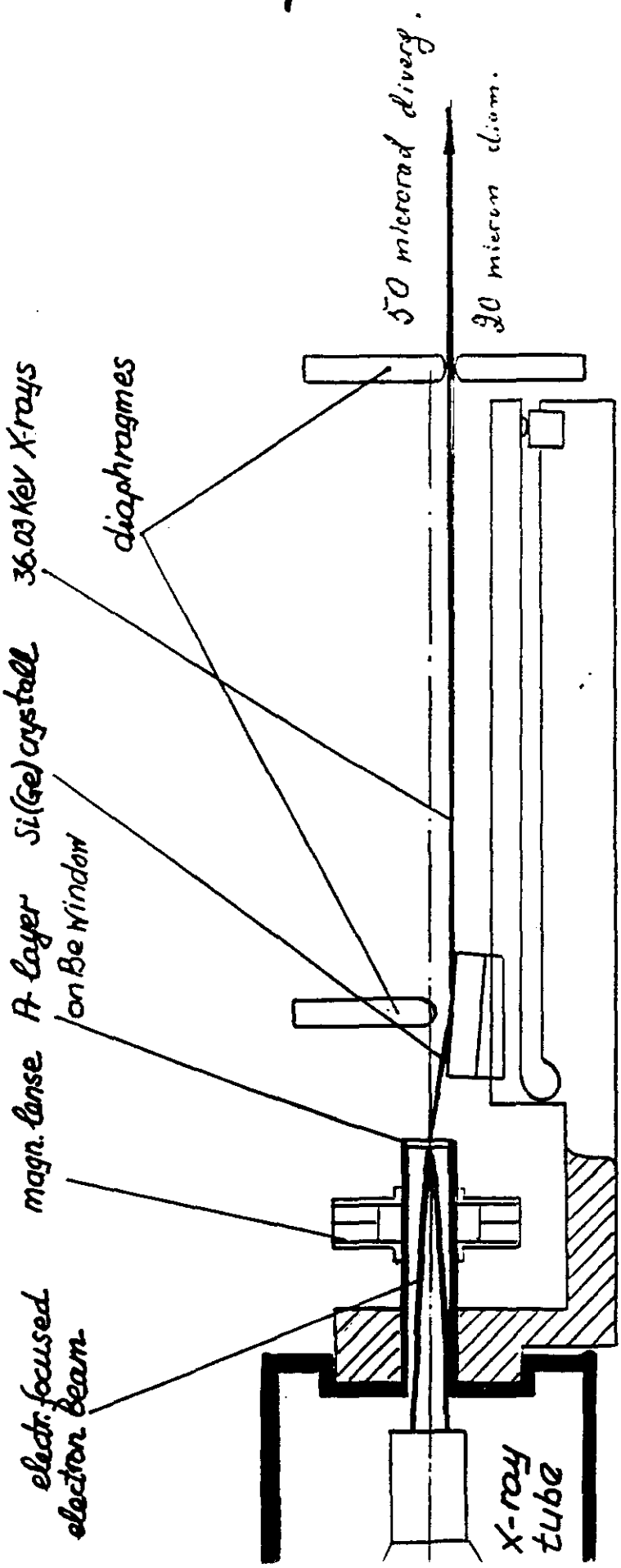
Z– shift vs position track for different entry angles



V

X - RAYS TESTS

This was proposed.



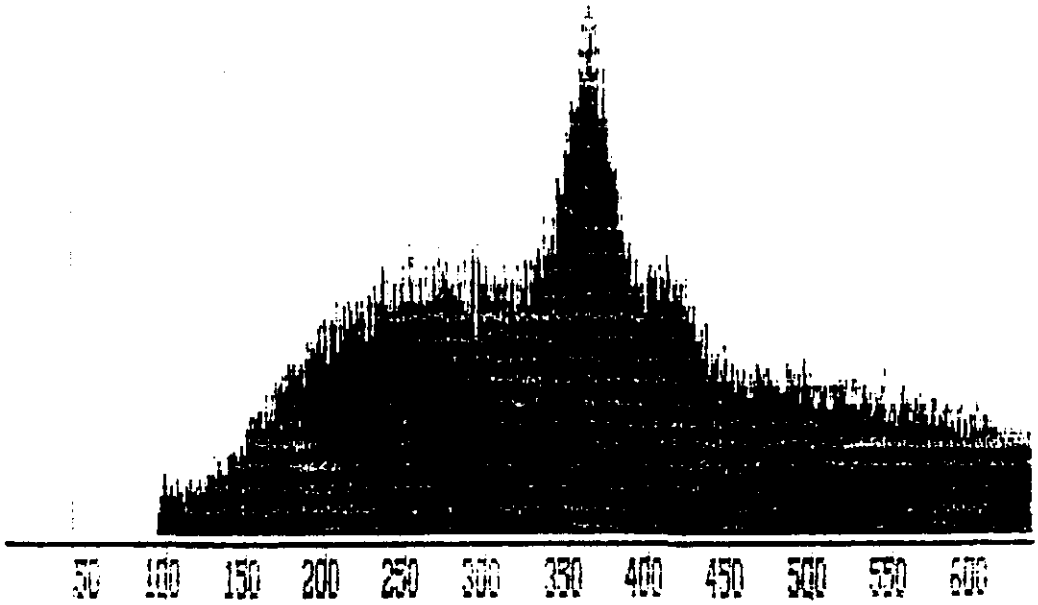
REIS - 100
X-rays tube with Pr anticathode

V = 100 kV
I = 60 μA without magn. focusing
I = 25 μA with magn. focusing

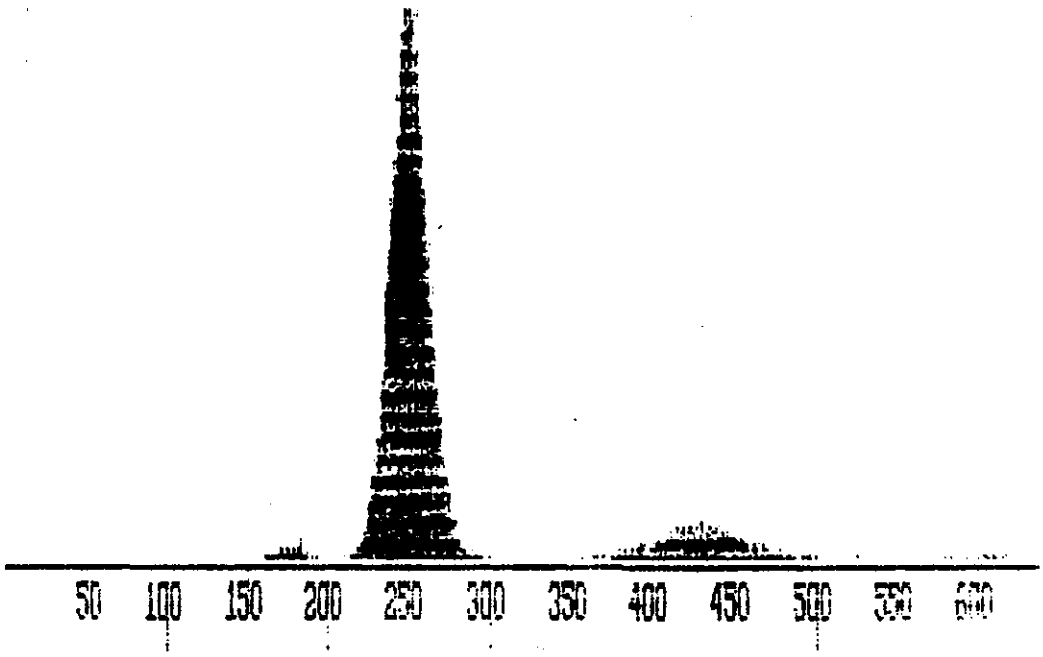
Preliminary test results
(without magn. focusing)
Monochromator Si (111) planes
Reflex width 70 mkm
Angle width < 50 mkrad
Reflex counting rate 10^3 per. sec for K_{α_1}
(for V = 95 kV I = 30 μA)

Now it is done.

36 keV



36 keV

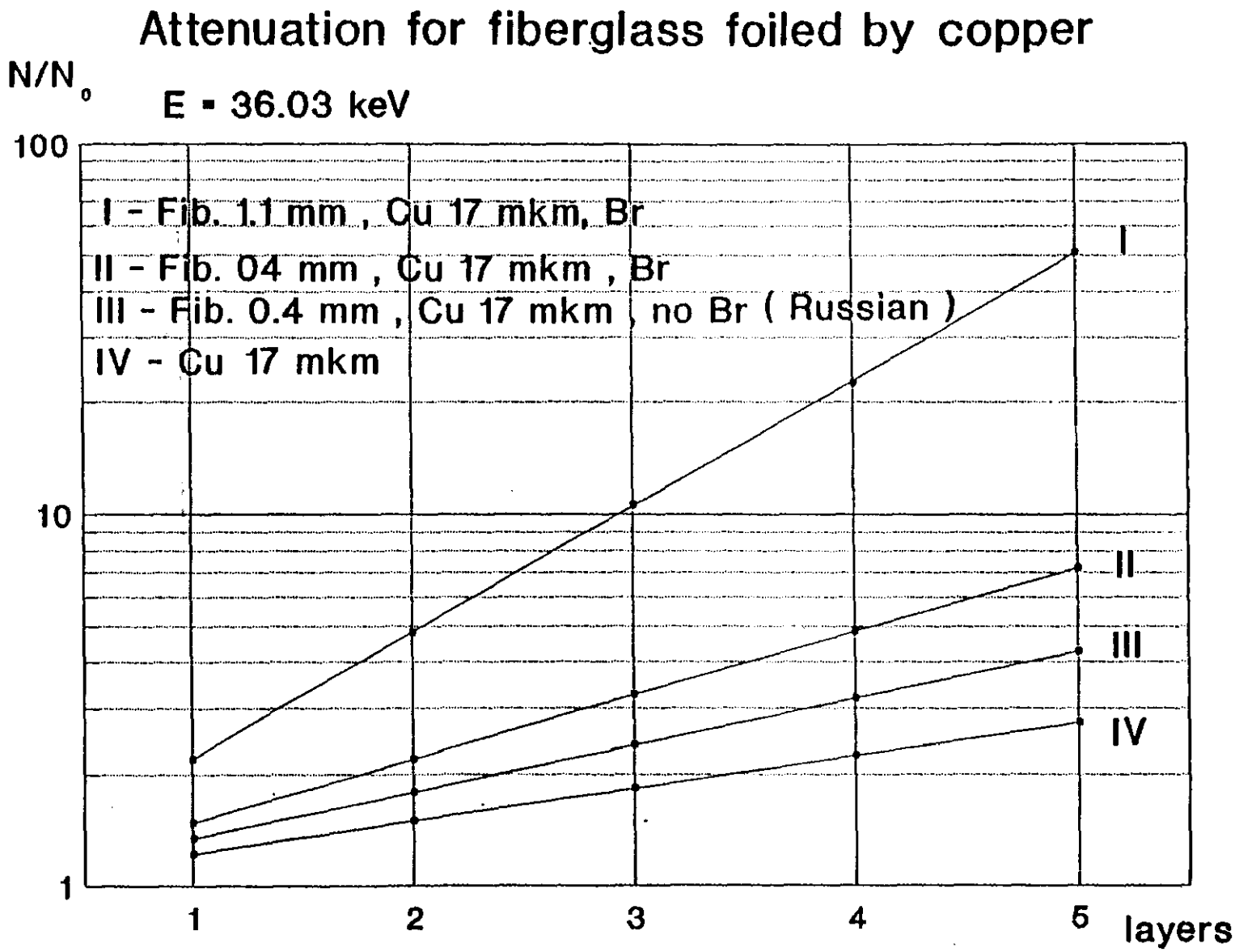


X ray spectra measured with a Ge detector.

a) without monochromator

b) with monochromator

Experimental data.



Presentation by:

Coleman Johnson

MUON SYSTEM PROGRESS

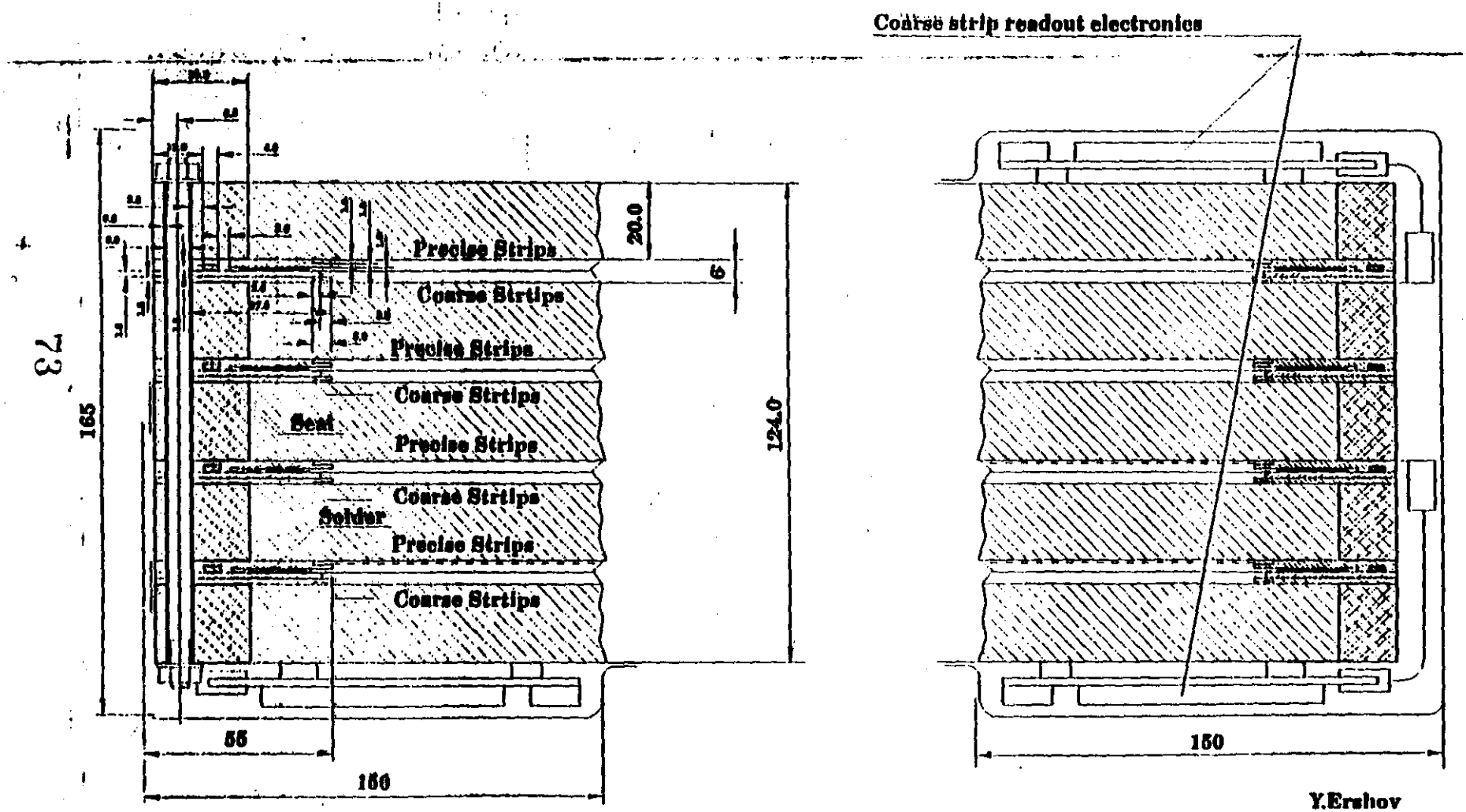
Presented at SSCL
Engineering Meeting

January 21, 1993

Coleman Johnson
Frank Nimblett
Rick Sawicki

BARREL CSC

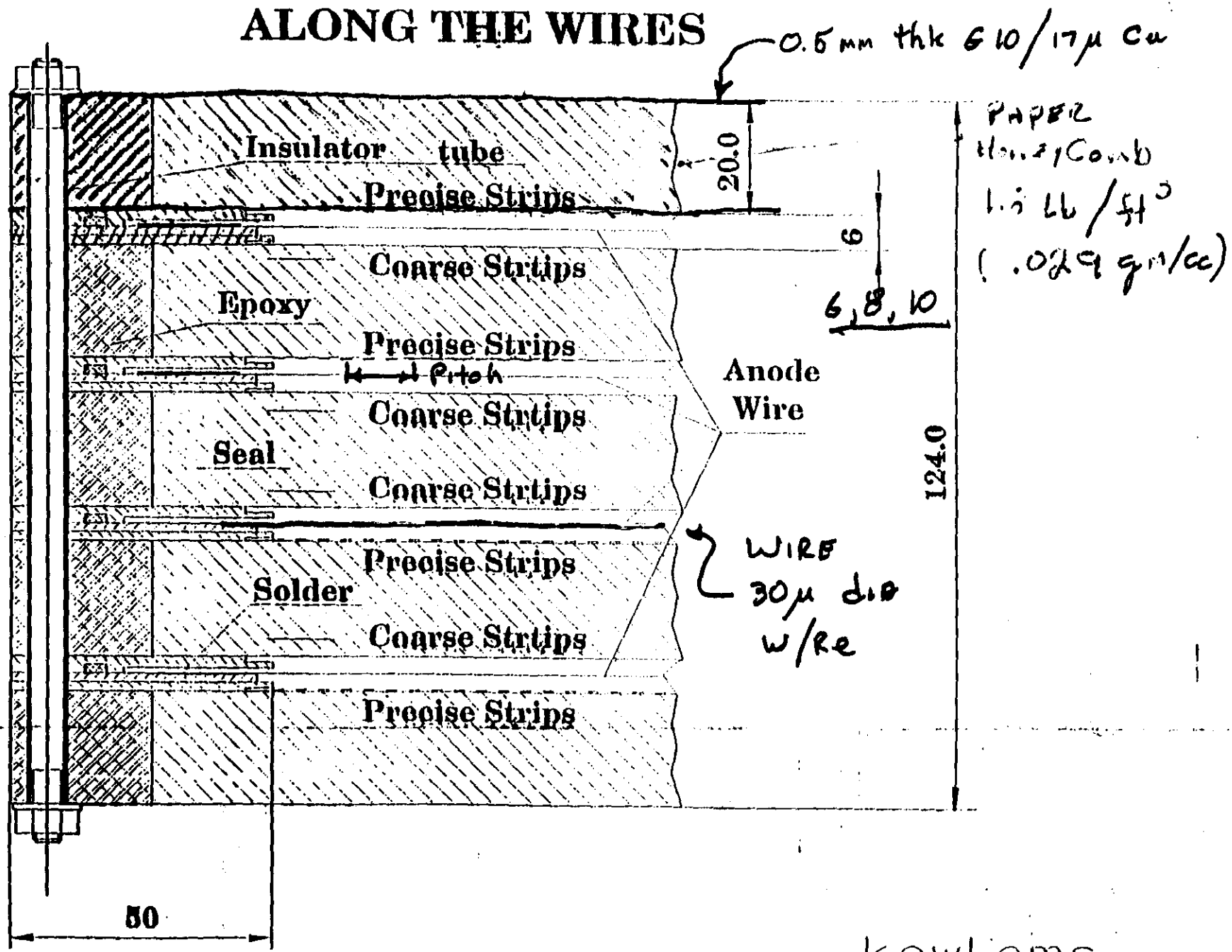
CROSS SECTION ALONG THE WIRES (B-B)



Y.Ershov
I.Golutvin
V.Lysiakov
S.Movchan

_k34.ems

CROSS SECTION ALONG THE WIRES



_kcwl_ems

· Strip cathode

- strip readout pitch is different for layers

- gap 3 MM – 5.5 MM
- gap 4 MM – 8.1 MM
- gap 5 MM – 10 MM

- Each strip channel consist of one readout and two floating strips
- strip gap – 0.4 MM
- cooper thickness - 17 μk

· wire plane

wire spacing 2.5 mm

wre Ø 30 μk

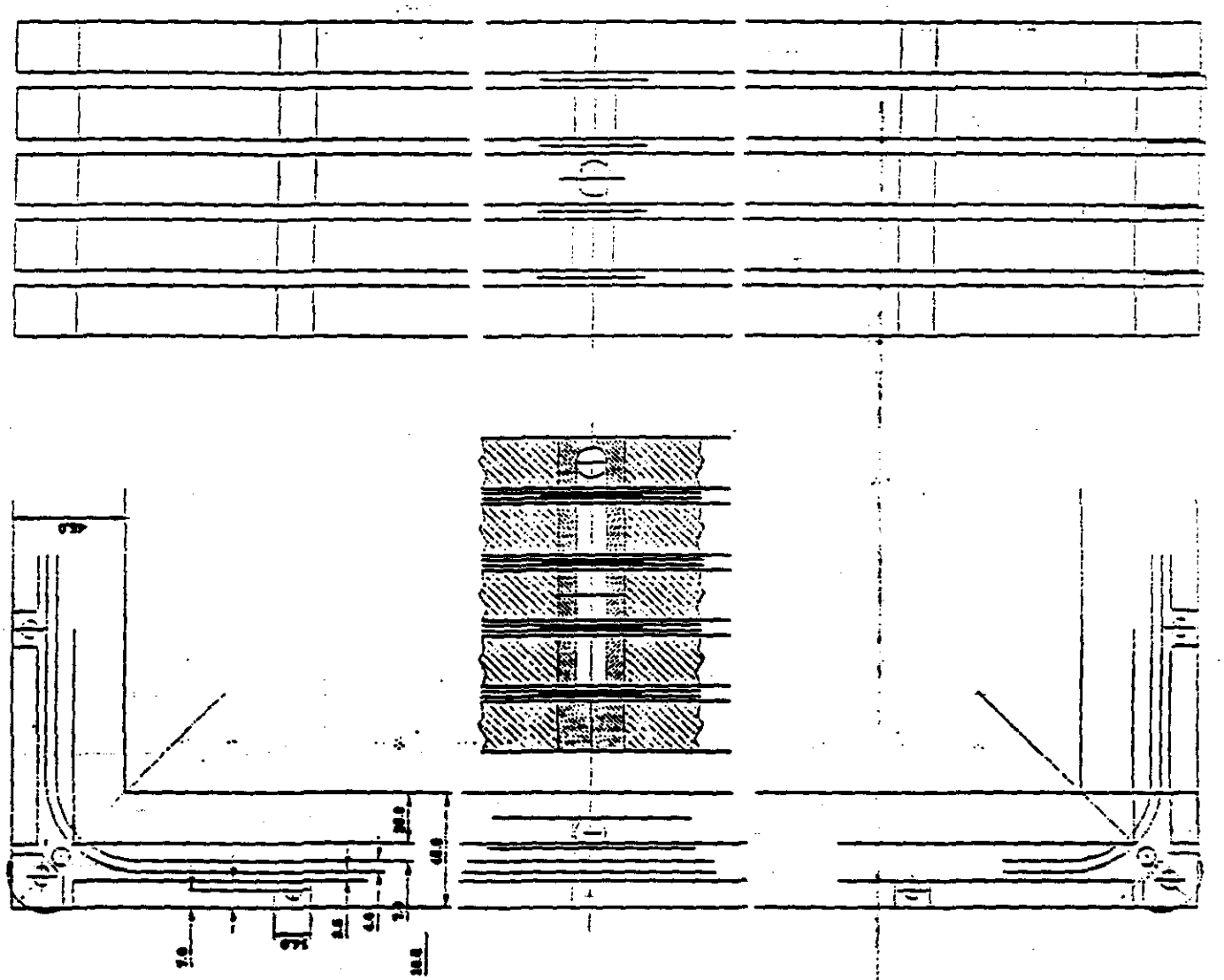
wire tension ≥150 g

the wires are soldered to the printed board and glued by epoxy

all the wires are grouped in groupes of 40 wires

?

30 ?



k38.cms

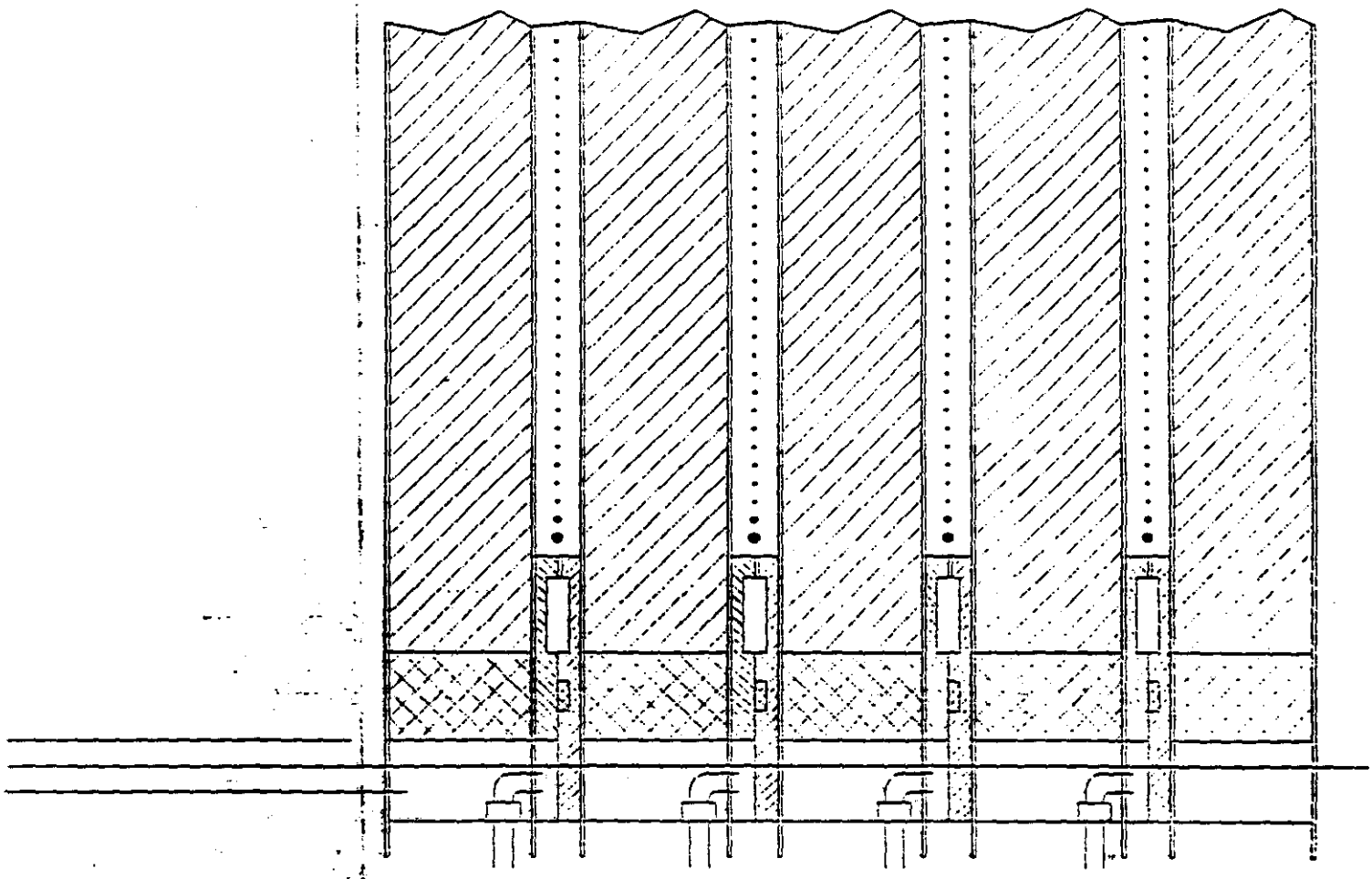
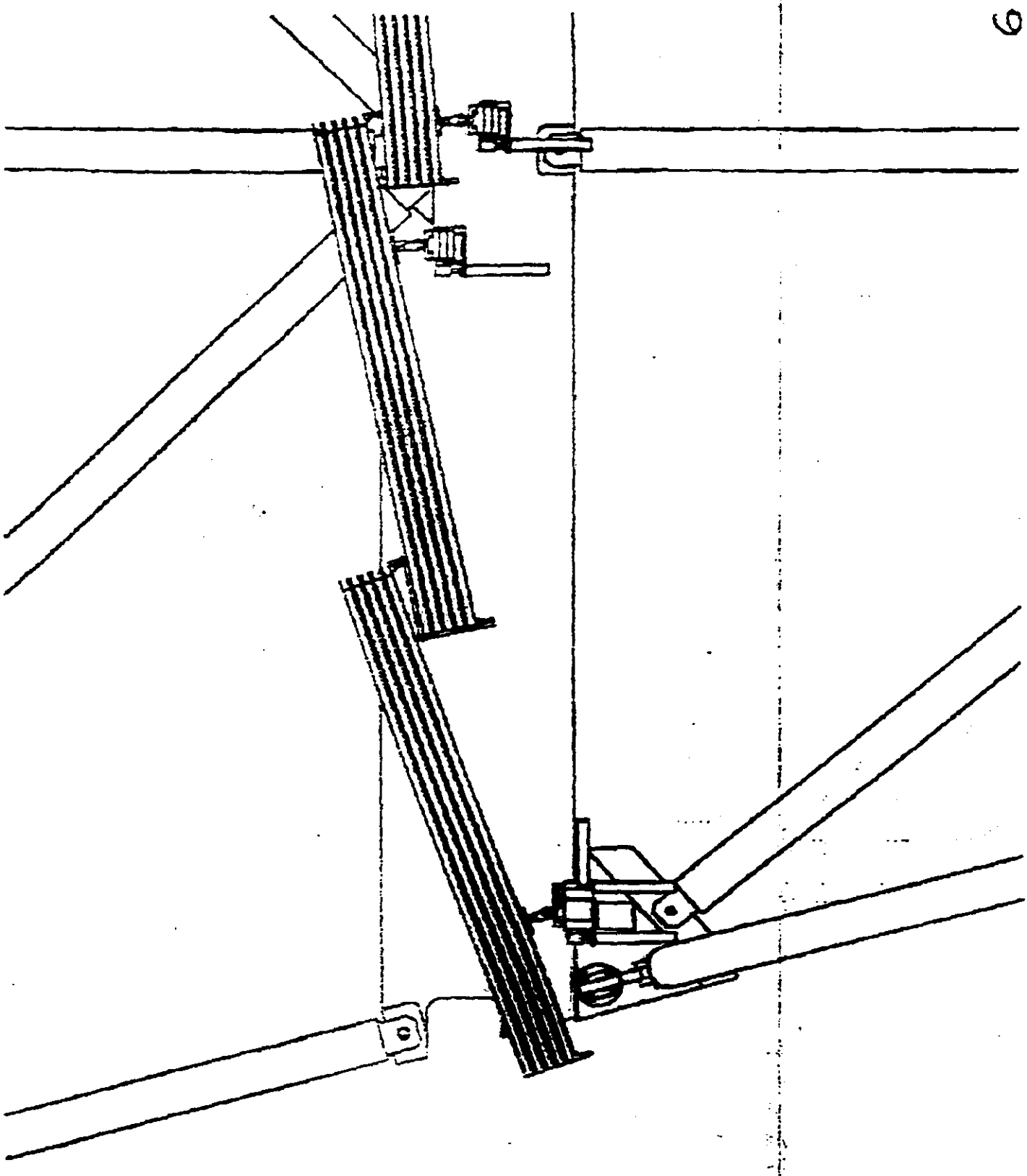
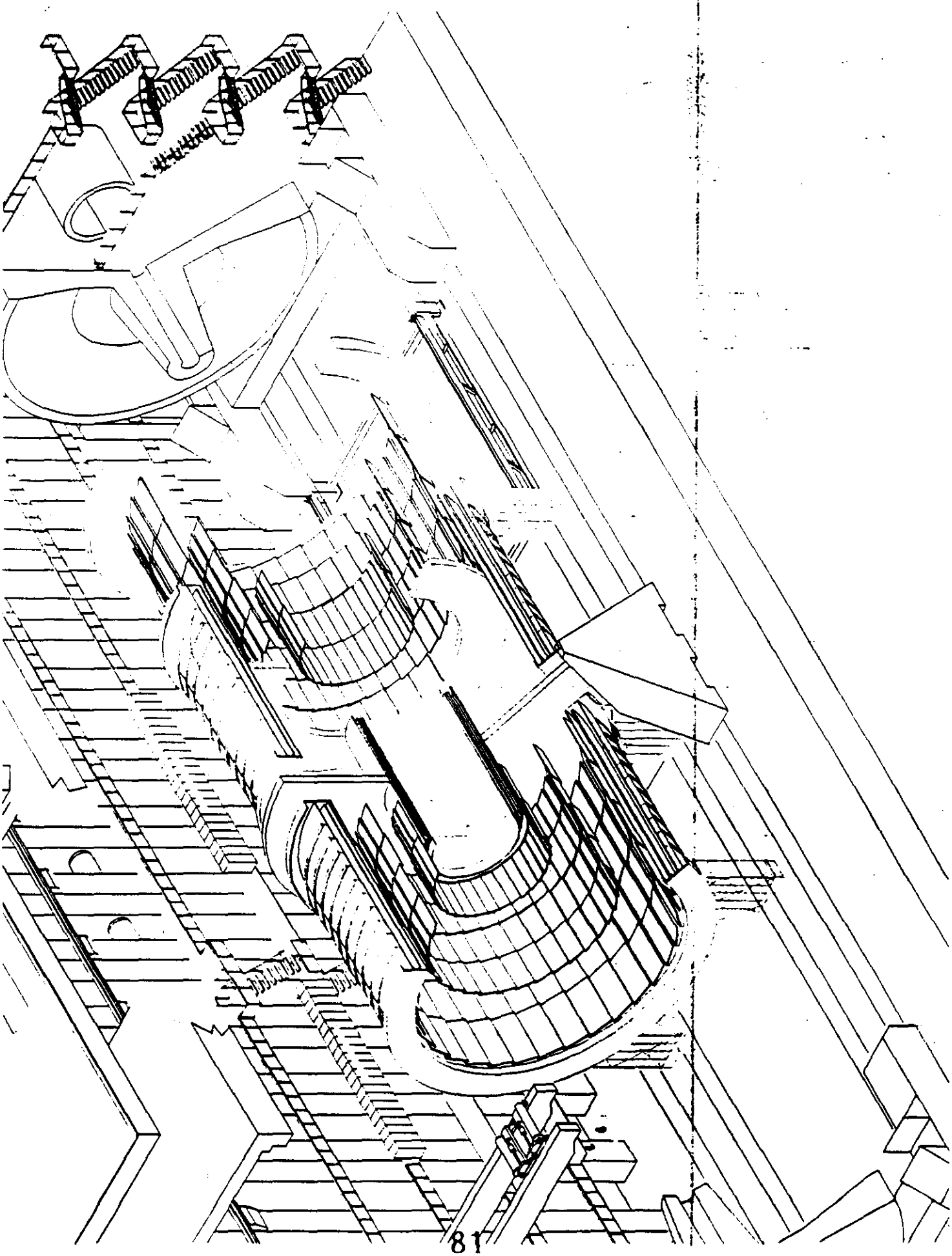
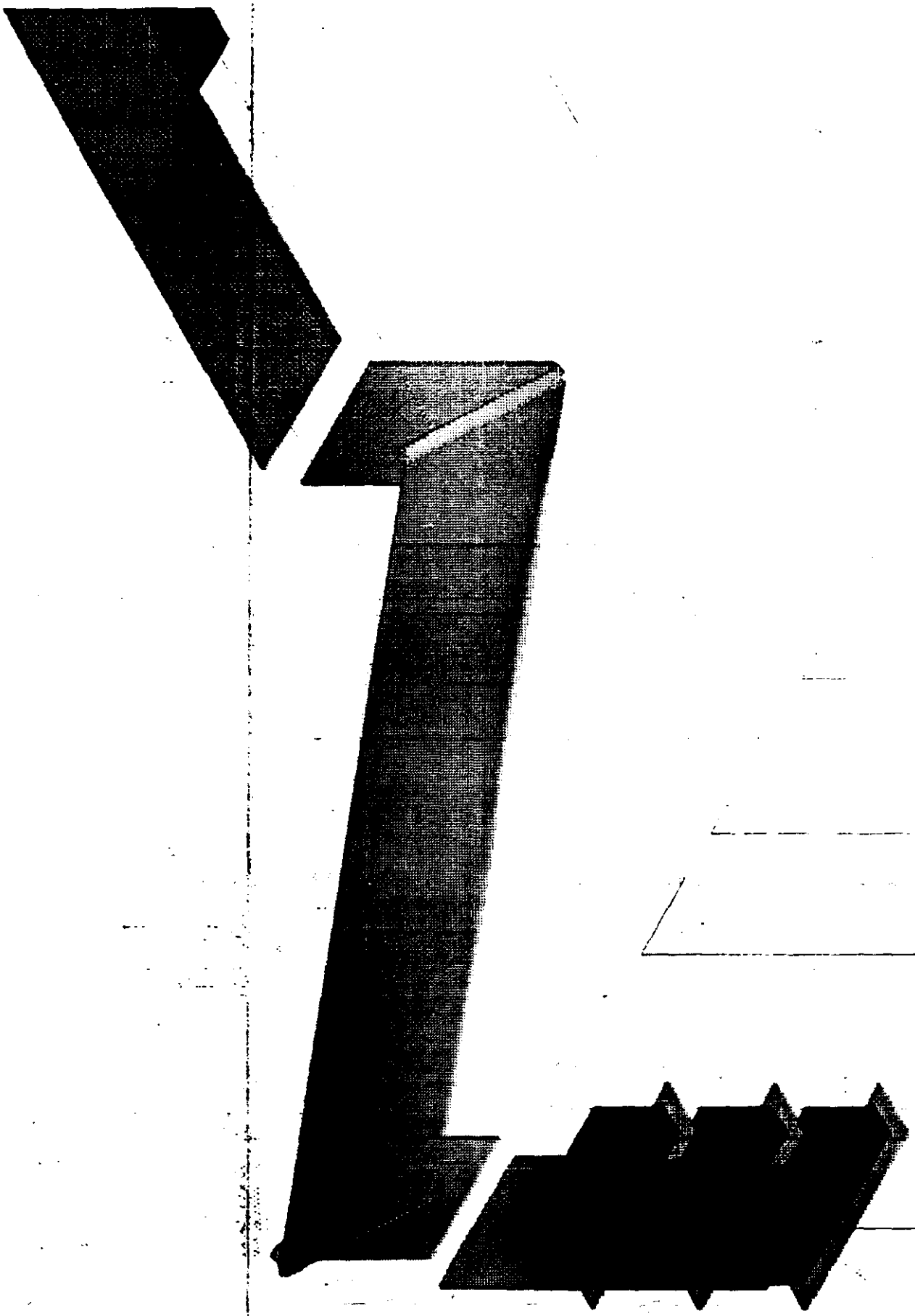


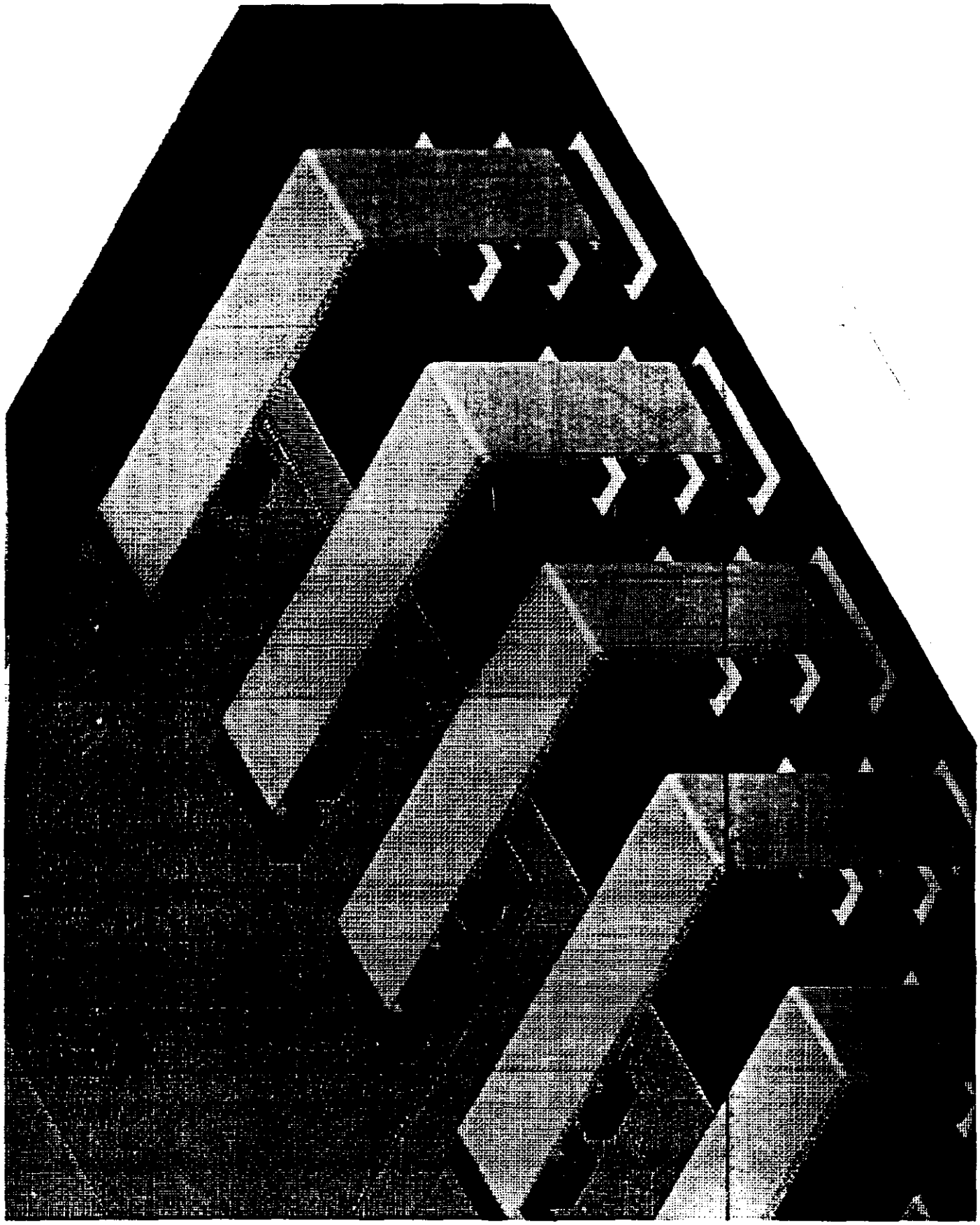
FIG. 10



JAN 13 '93 13:01 FROM LLNL ME/MEED PAGE.007
PAGE.007







gem

γeμ

Presentation by:

Dan Marlow

CSC Muon Electronics

Dan Marlow
Princeton University

January 26, 1993

GEM CSC Readout Design Goals

- Equivalent noise charge ($\sim 3000\ e^-$) rms (for $\tau = 300$ ns)
- Dynamic Range
  - 50 μm measurement for strip width $w = 5$ mm

$$\frac{\sigma_s}{w} \simeq \sqrt{2}\frac{\sigma_q}{Q} \Longrightarrow \frac{Q}{\sigma_q} \simeq \sqrt{2}\frac{w}{\sigma_s} = 140$$

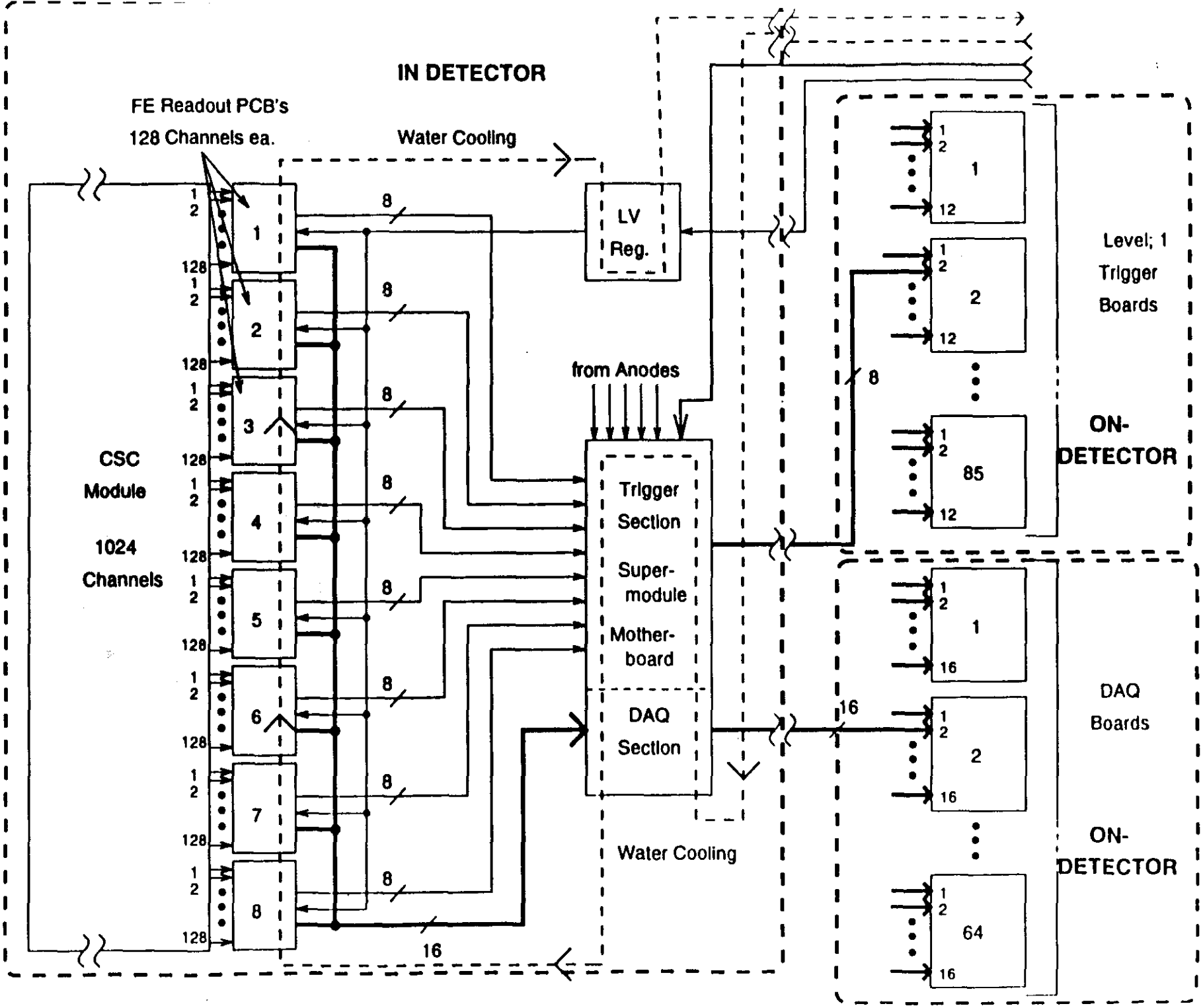
$\Longrightarrow$ 7.1 bits

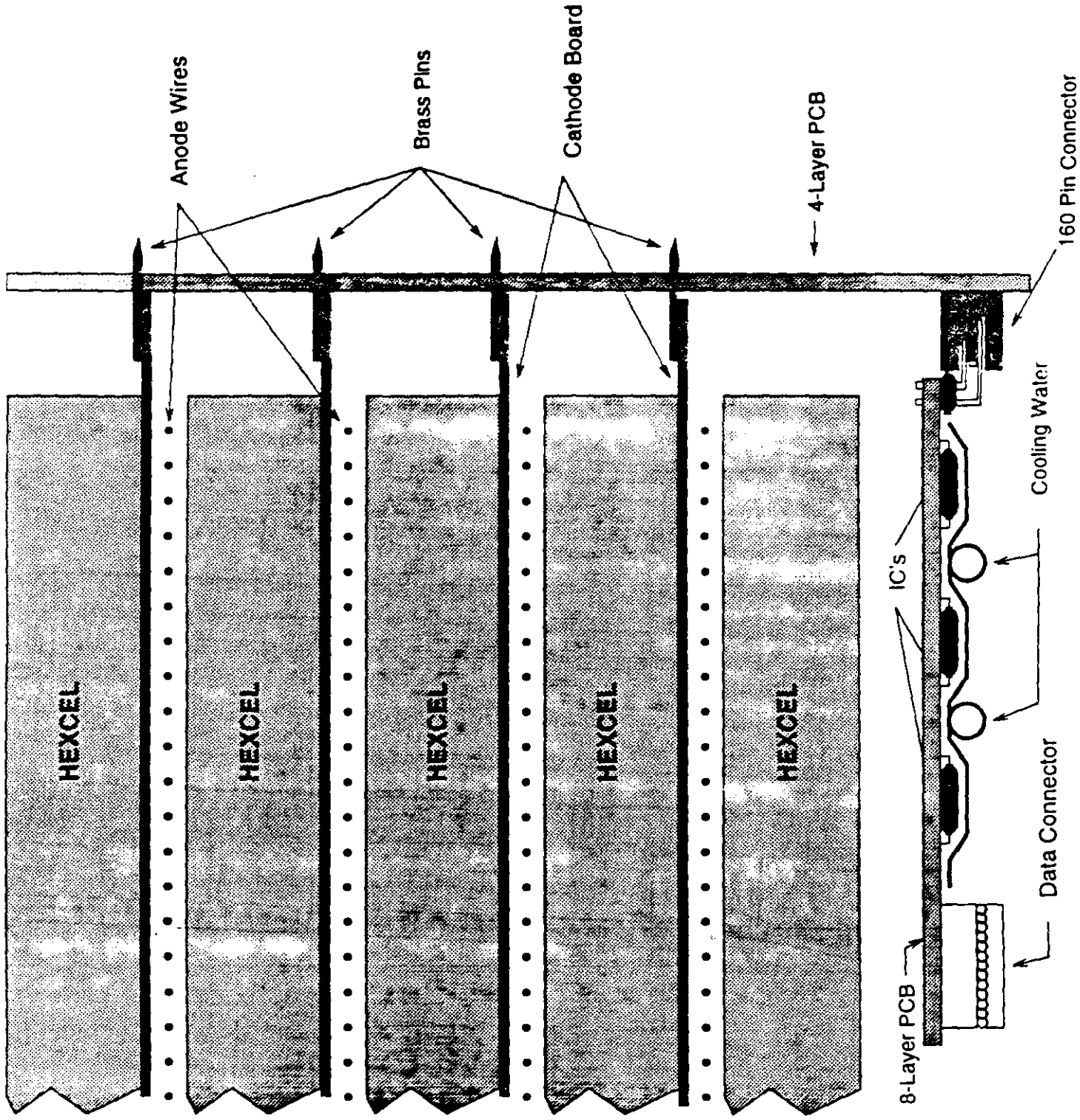
  - Landau tail $\varepsilon \simeq 95\% \Longrightarrow 40 - 230\ e^-$

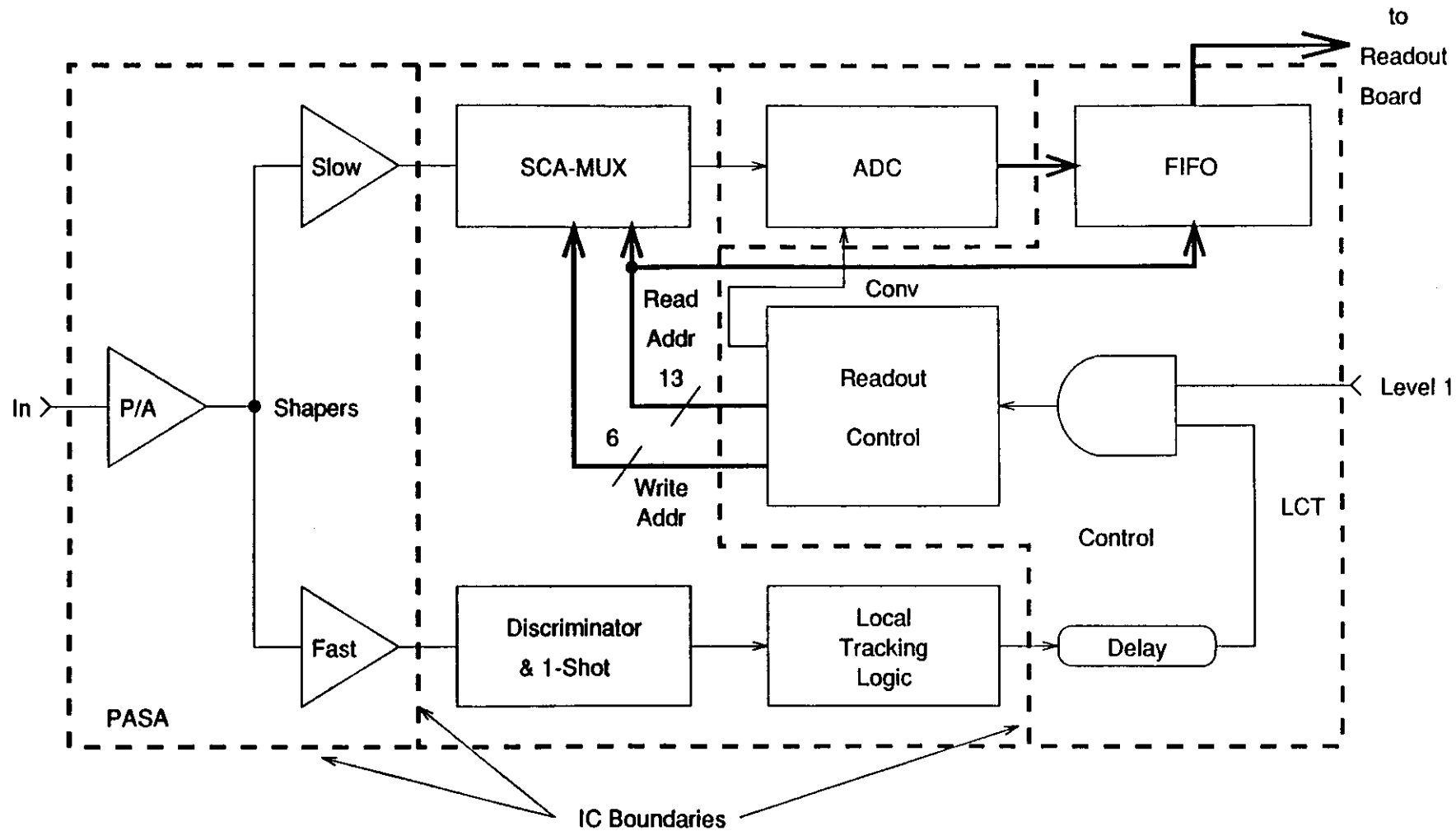
$\Longrightarrow$ 2.5 bits

  - $\times 2$ Design margin $\Longrightarrow$ 1.0 bits
  - Total $\Longrightarrow$ 10.6 bits

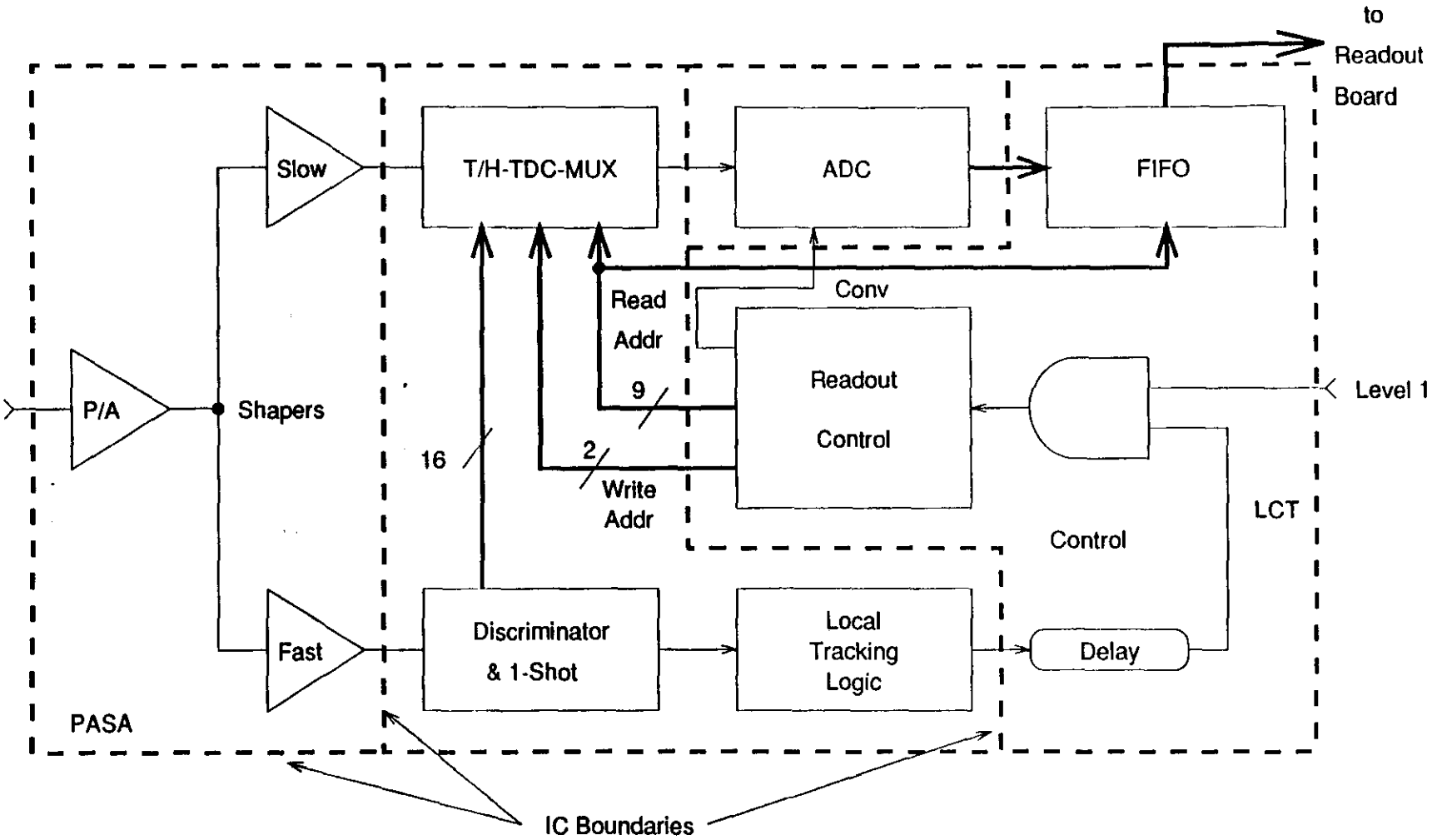
- $< 10\ \mu$s conversion time (Level 1 Accept Rate)
- Time resolution $\sim$ BX (for rejection of neutron hits)
- Low cost ($\sim$ \$10. – \$20. per channel)
- Radiation hard? $F_n \simeq 10^{13}$ cm^{-2} 10 SSC-yr^{-1} ?


IN DETECTOR
FE Readout PCB's
128 Channels ea.
Water Cooling
CSC
Module
1024
Channels
LV
Reg.
from Anodes
Trigger
Section
Super-
module
Mother-
board
DAQ
Section
Water Cooling
Level; 1
Trigger
Boards
ON-
DETECTOR
DAQ
Boards
ON-
DETECTOR
8
16
128
12
16
85
64

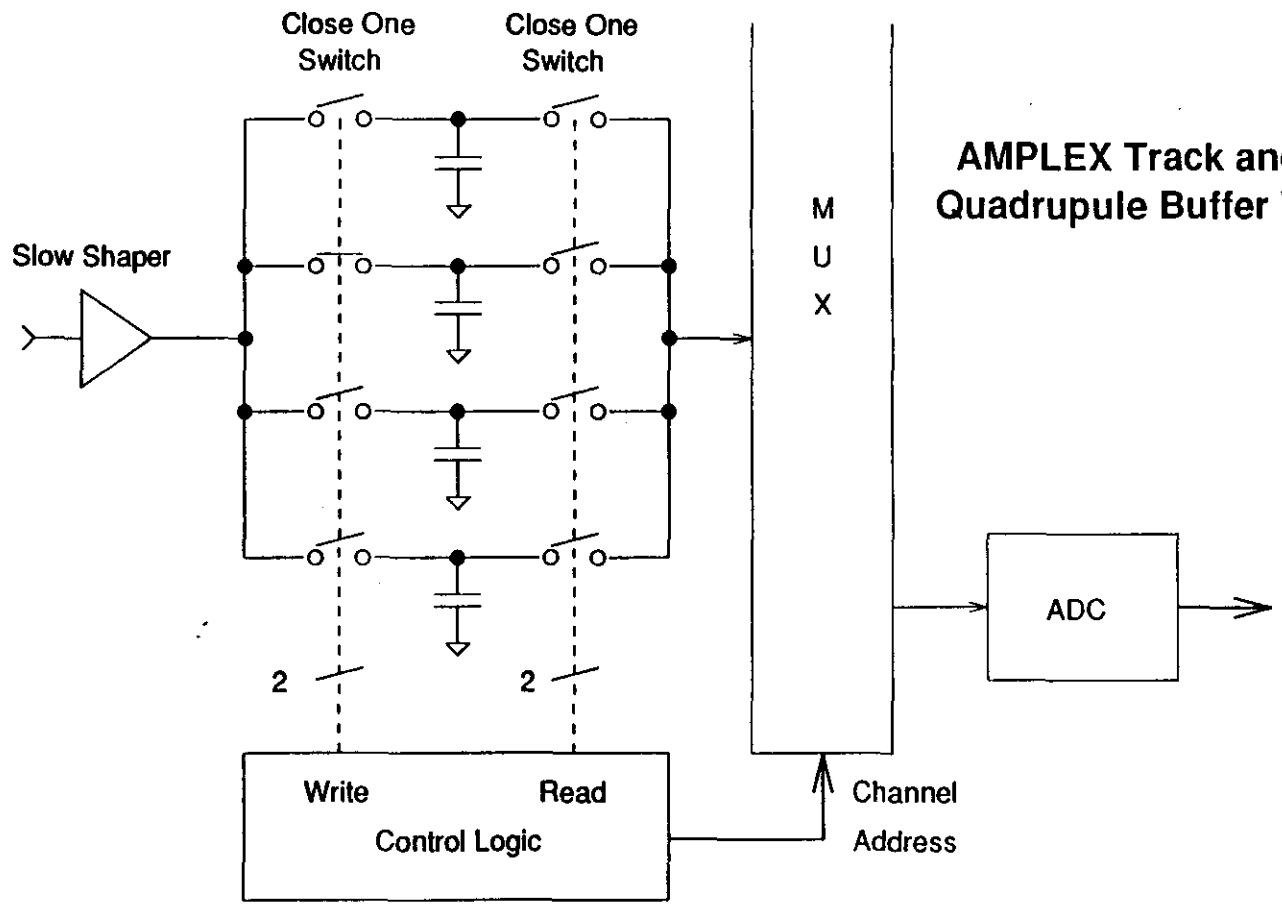

Anode Wires
Brass Pins
Cathode Board
4-Layer PCB
160 Pin Connector
Cooling Water
IC's
Data Connector
8-Layer PCB
HEXCEL
HEXCEL
HEXCEL
HEXCEL
HEXCEL



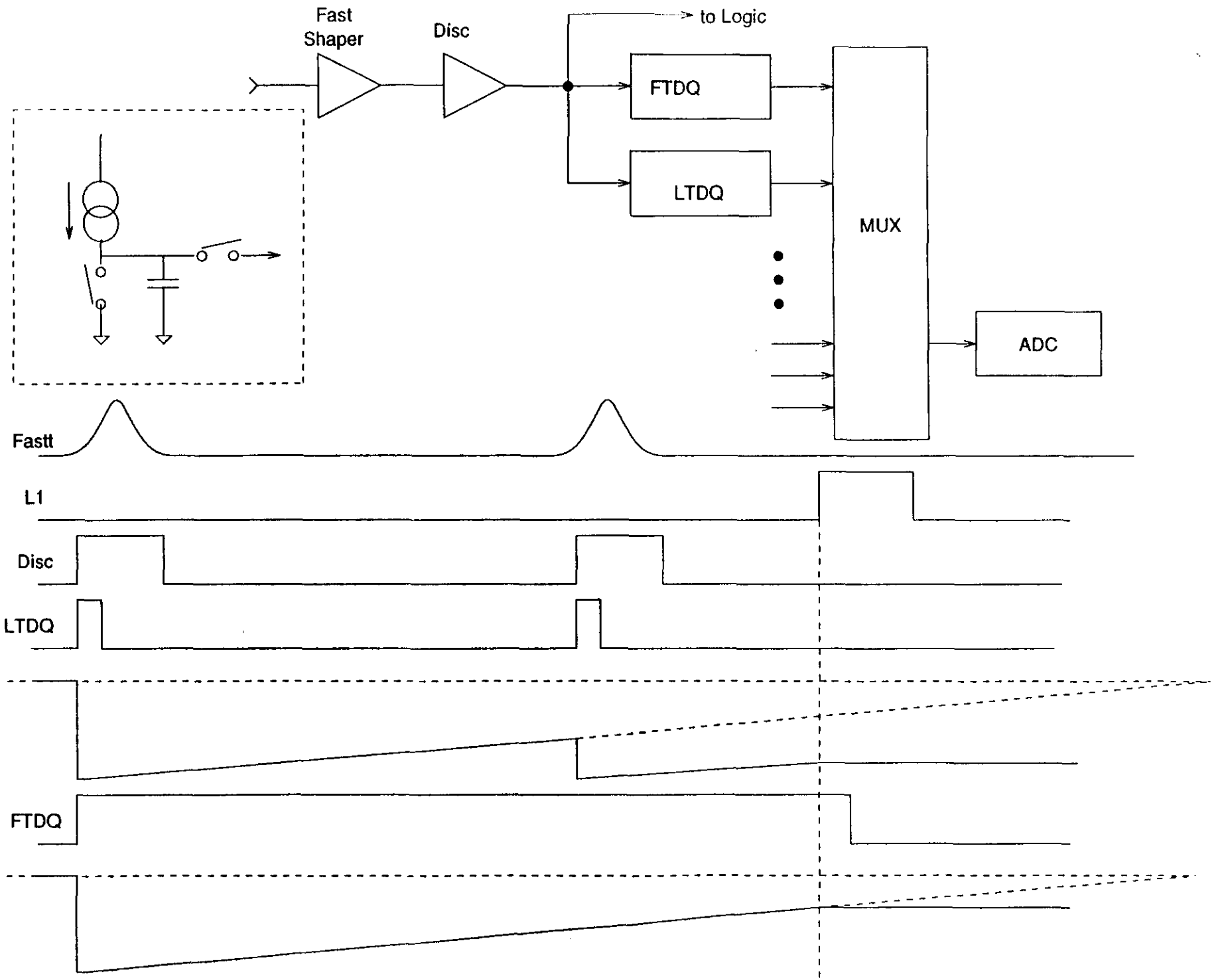
CSC Front End Board Block Diagram
SCA Version

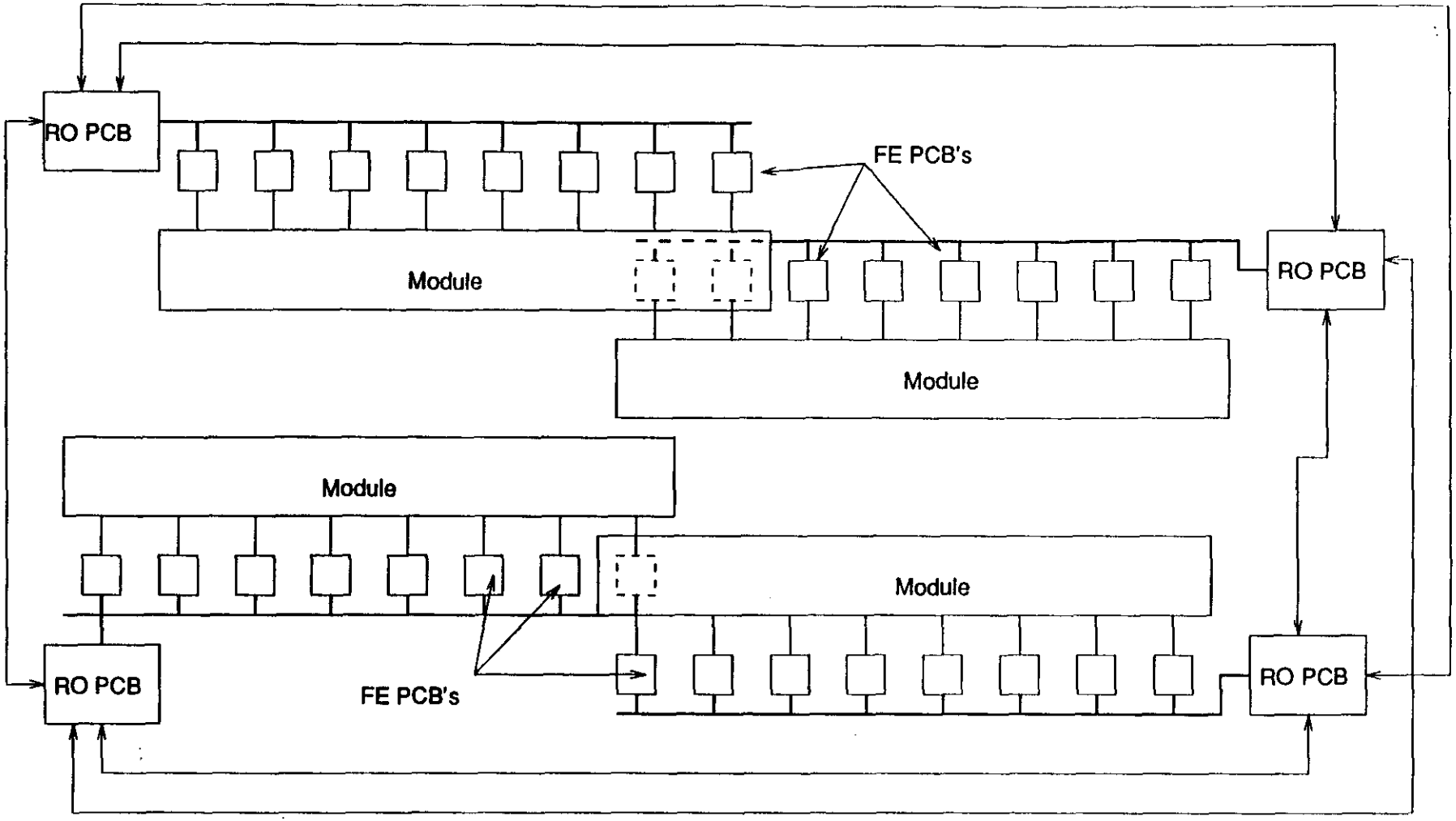


CSC Front End Board Block Diagram
Modified Amplex Version



AMPLEX Track and Hold Quadrupule Buffer Version


Fast
Shaper
Disc
to Logic
FTDQ
LTDQ
MUX
ADC
Fastt
L1
Disc
LTDQ
FTDQ



2 of 3 Requirement may be "noisy" due to double hits from neutrons

Connection of modules at the RO PCB level is practical, although unpleasant

Connection of modules at FE PCB Level may be prohibitive

Two three-layer modules may create twice as many trigger signals.

A single six-layer module appears to be better from an electrical point of view.

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Presentation by:

Robert Wixted

CSC Muon Electronics

Robert L. Wixted
Princeton University

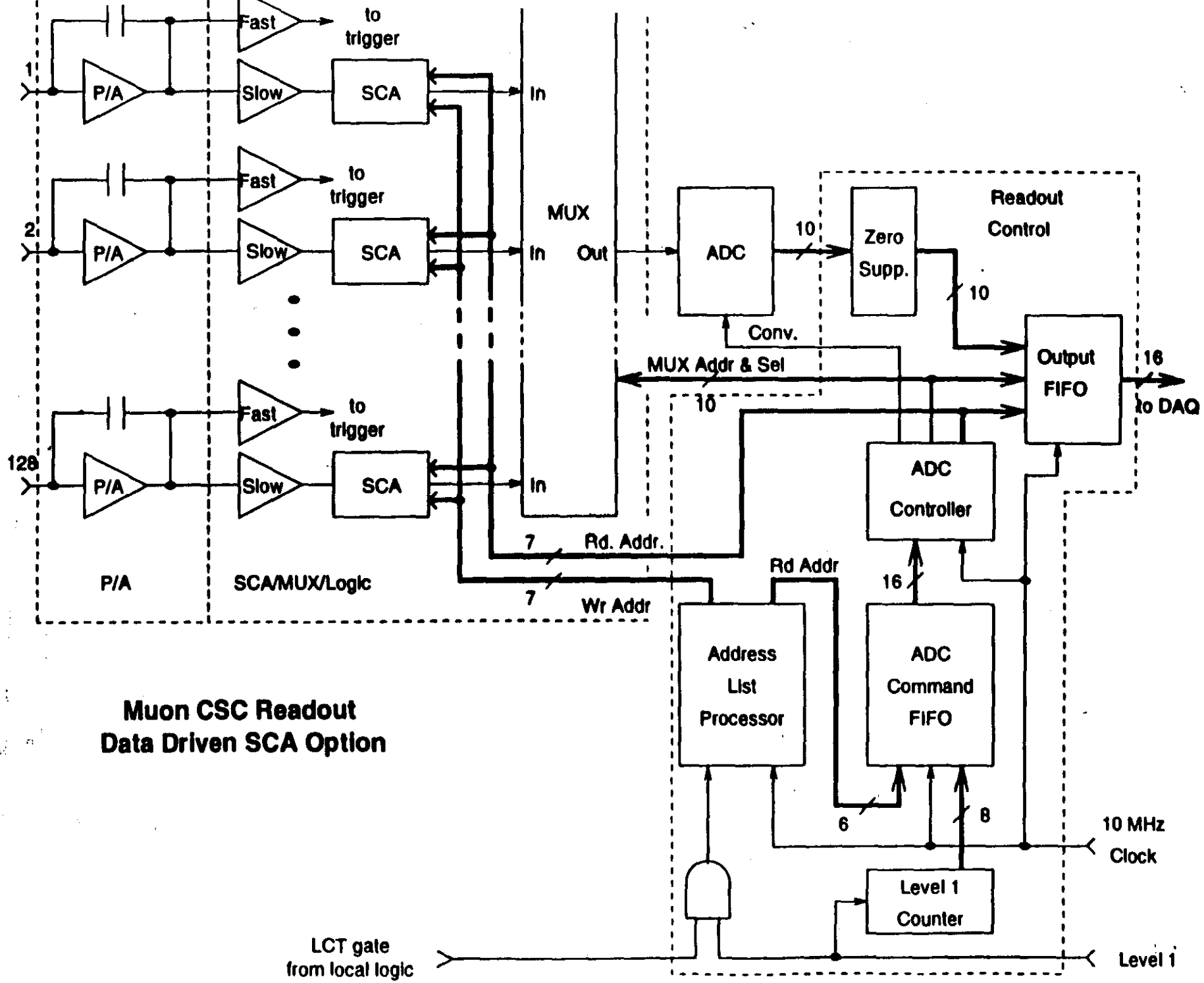
January 26, 1993

OUTLINE

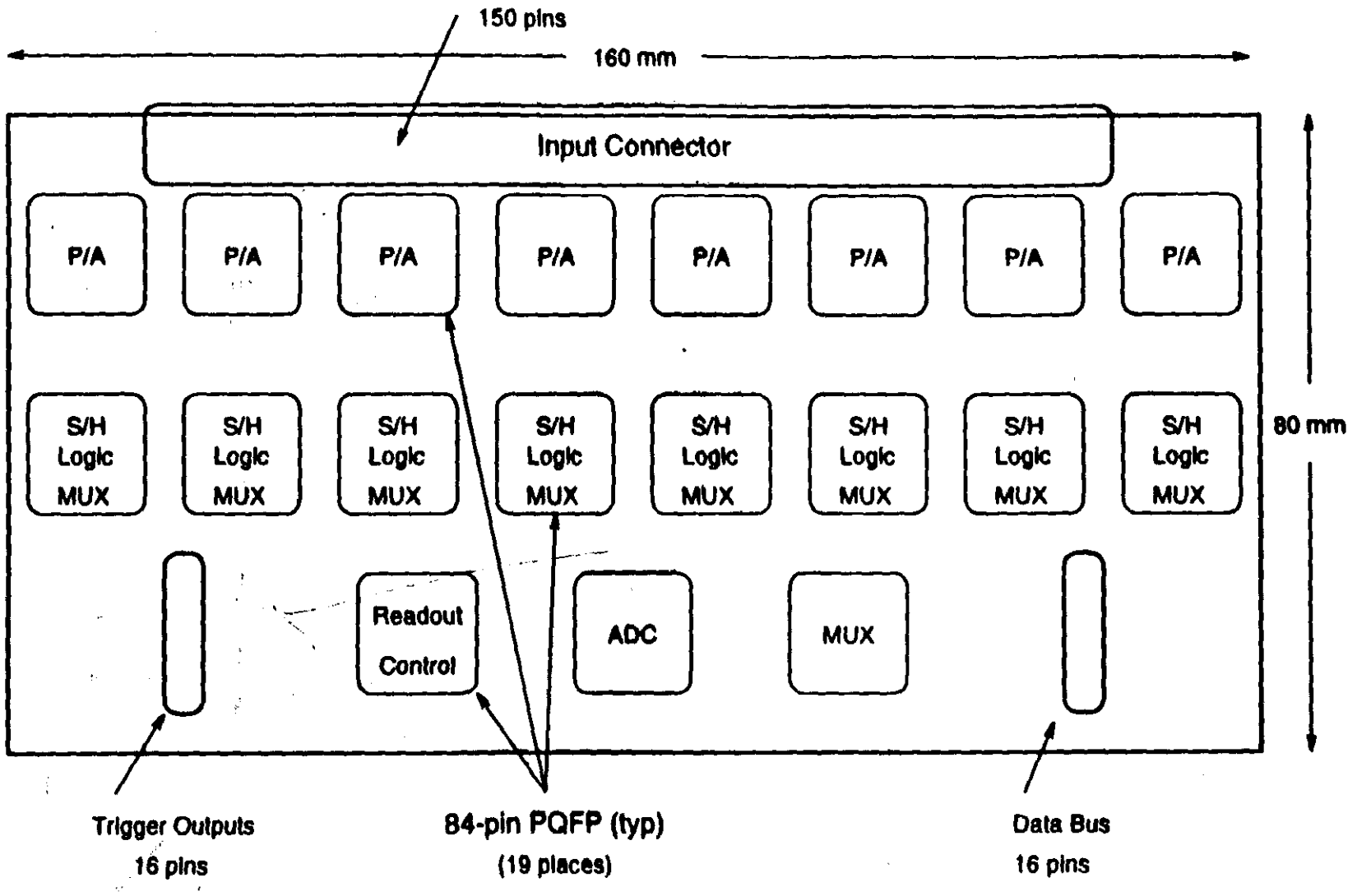
Block Diagram /Schematics

SCA Chip Layout

SCA Subcircuits

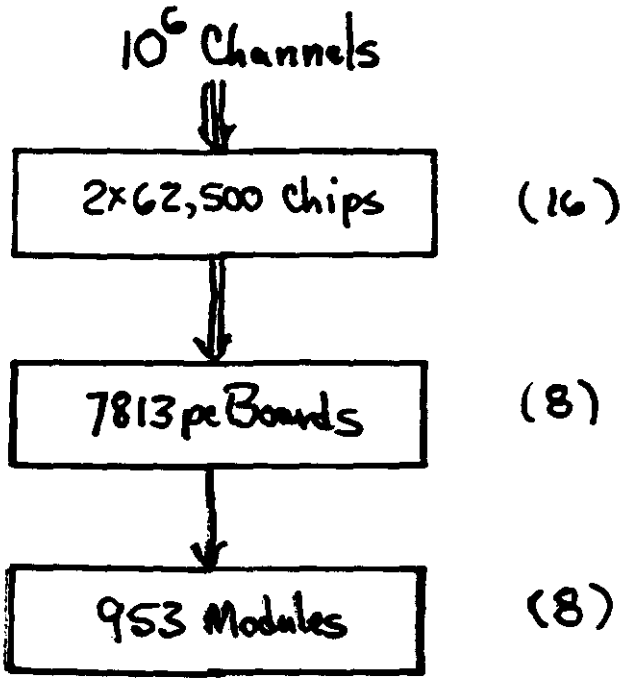


Muon CSC Readout
Data Driven SCA Option

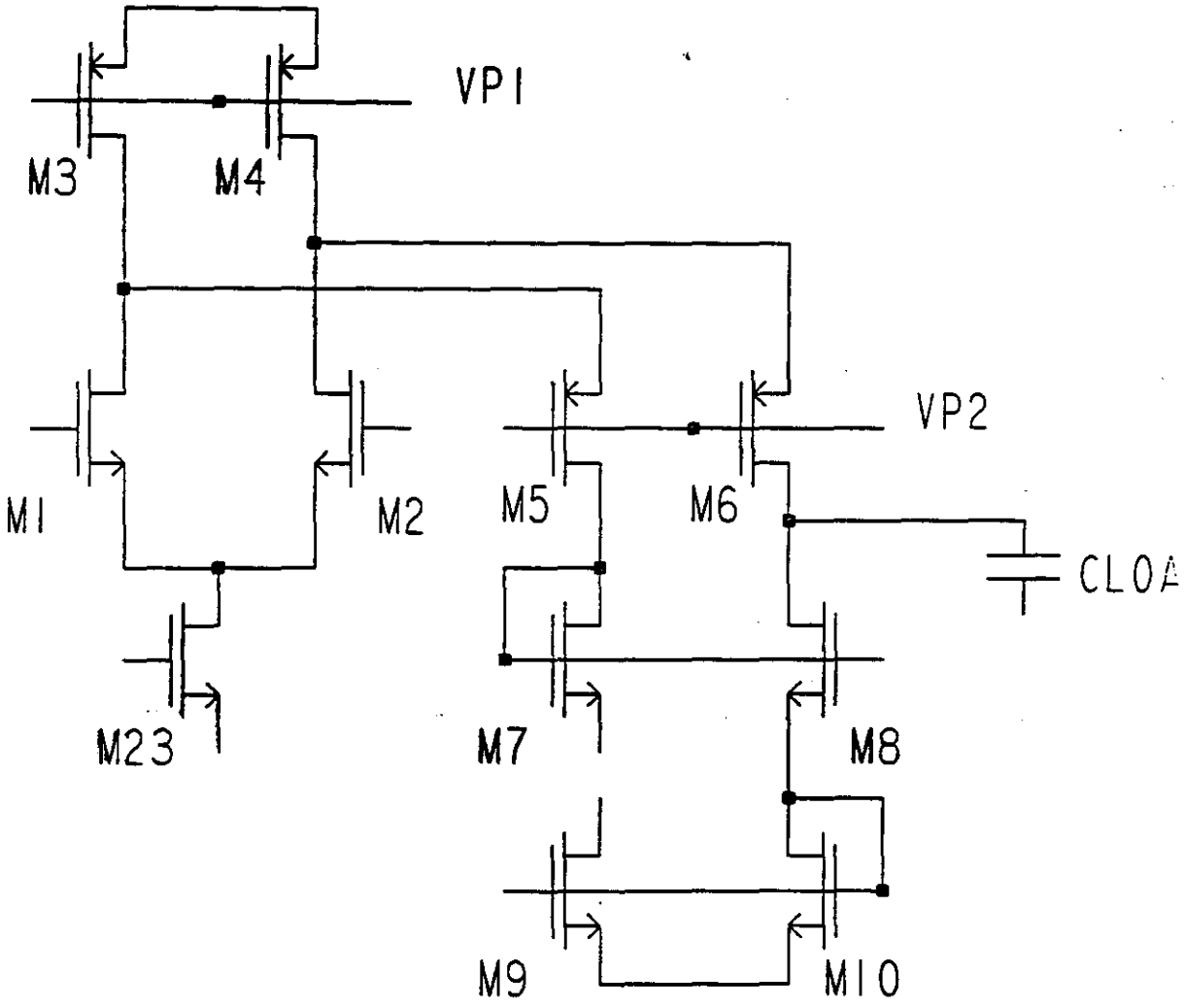


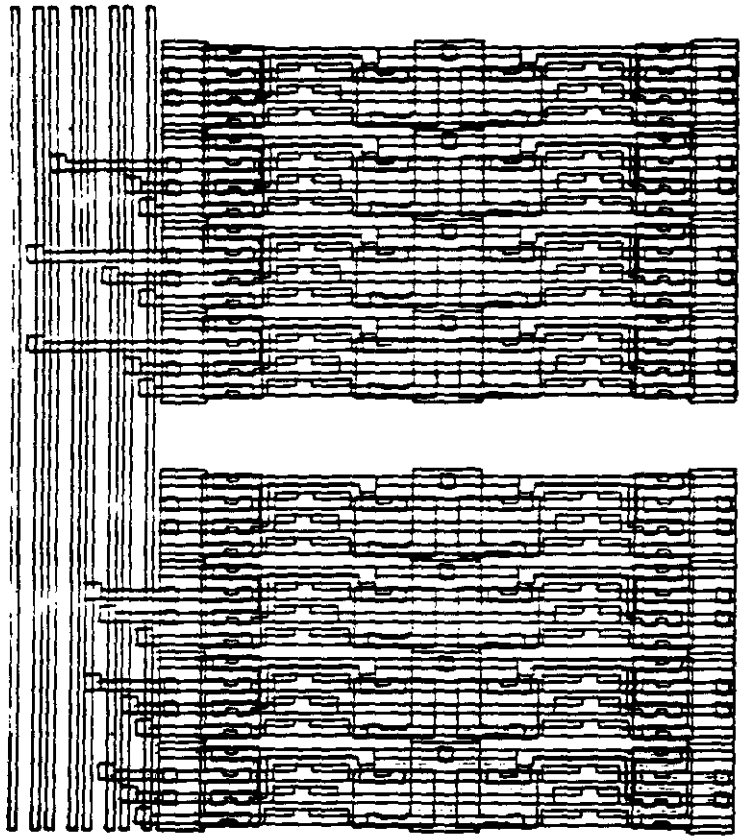
CSC Chamber Board Layout
128 Channel Version

PACKAGE SCHEMATIC

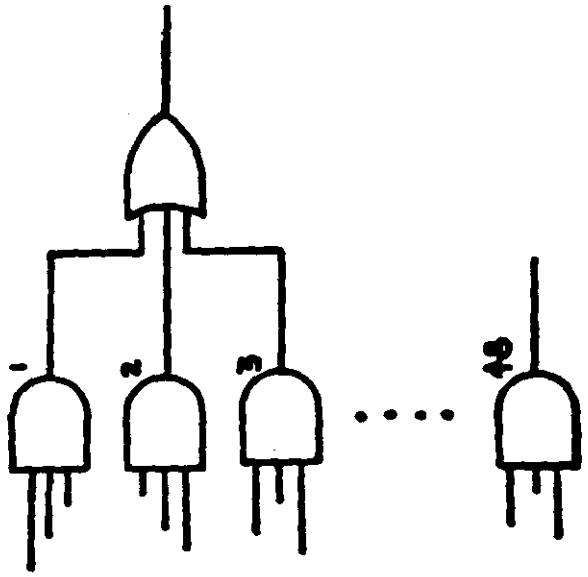


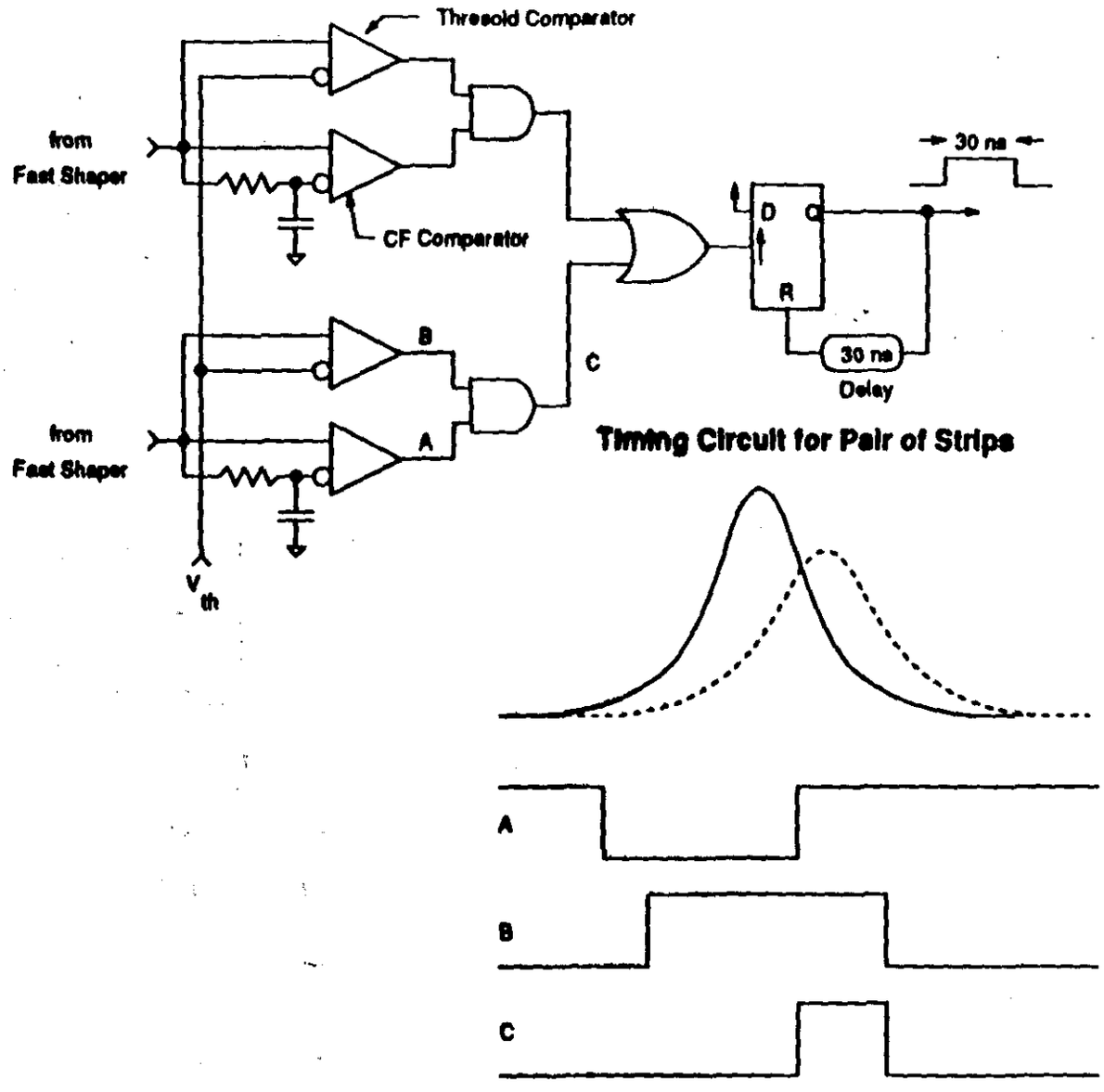
READOUT AMPLIFIER



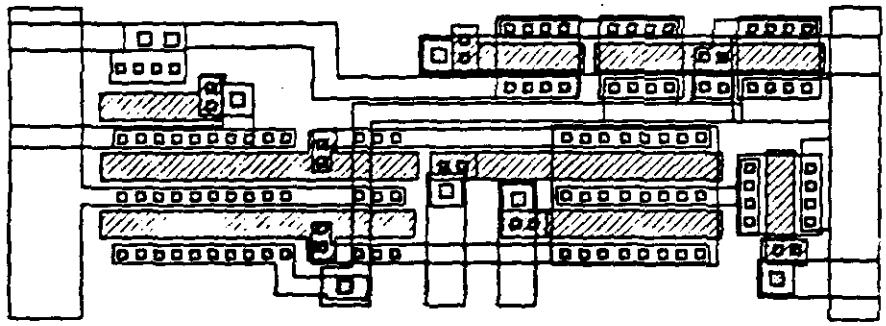


3/4 TRIGGER LOGIC

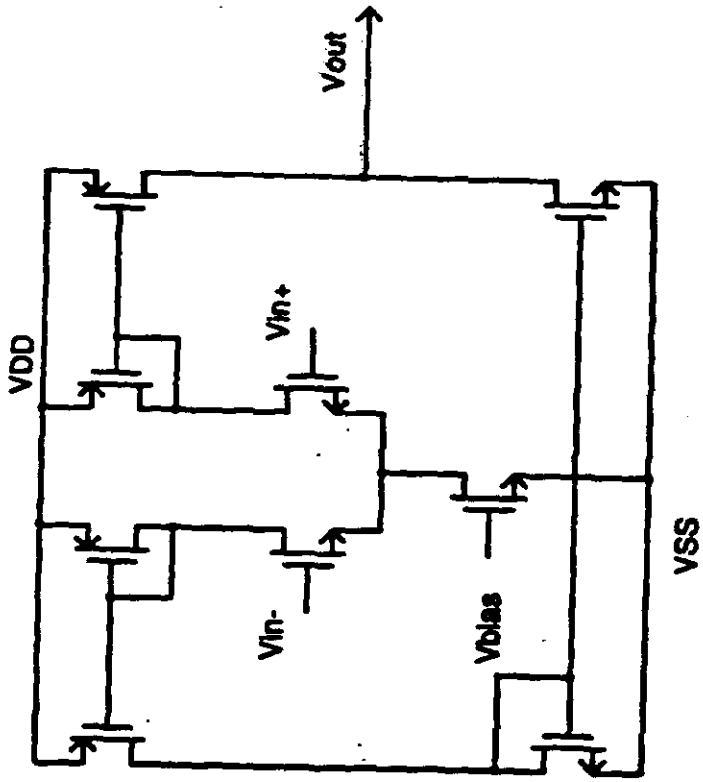




Timing Circuit for Pair of Strips



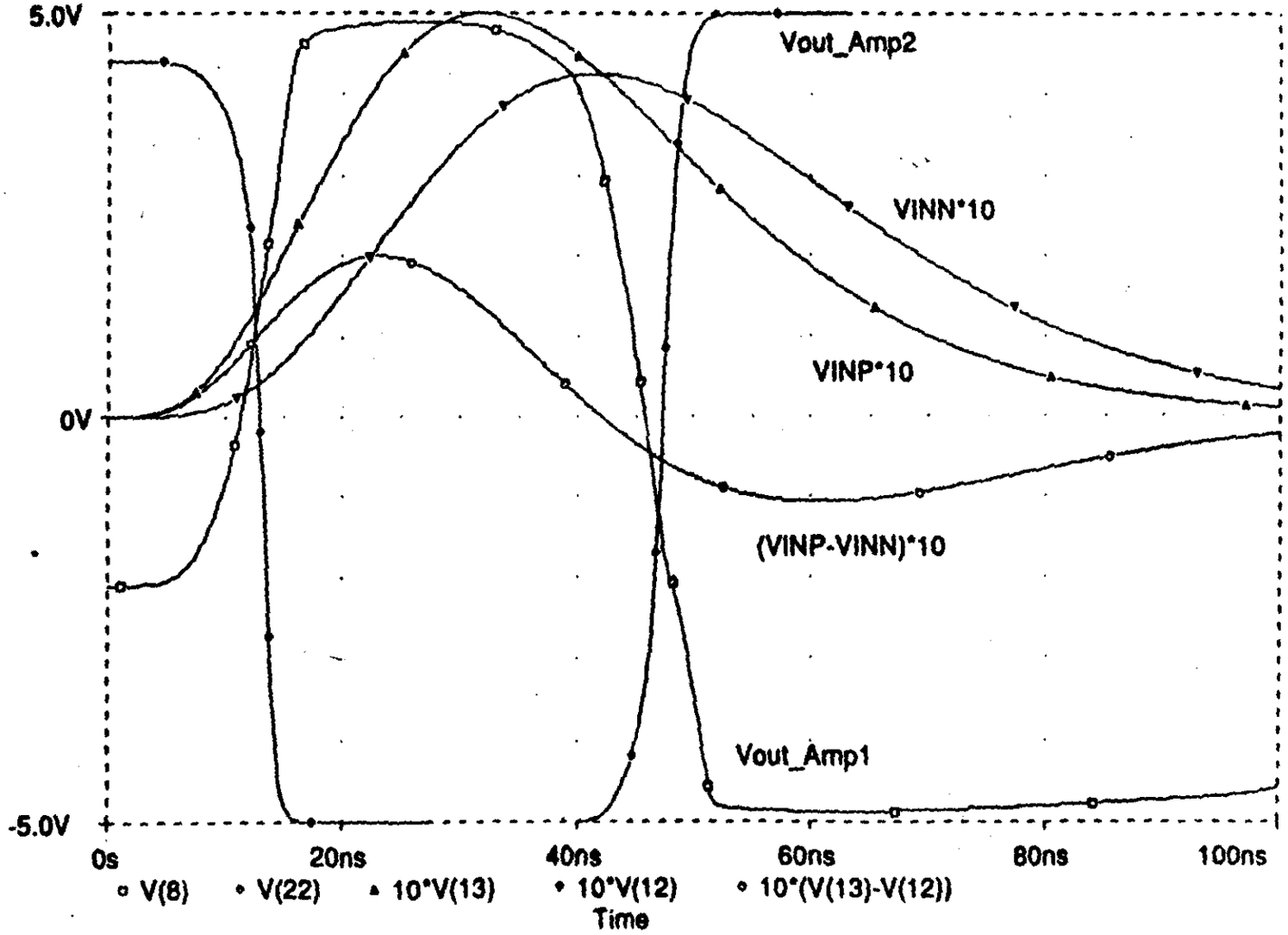
Discriminator Amplifier Schematic



Fast Timer Circuit

Date/Time run: 01/03/93 18:34:41

Temperature: 25.0

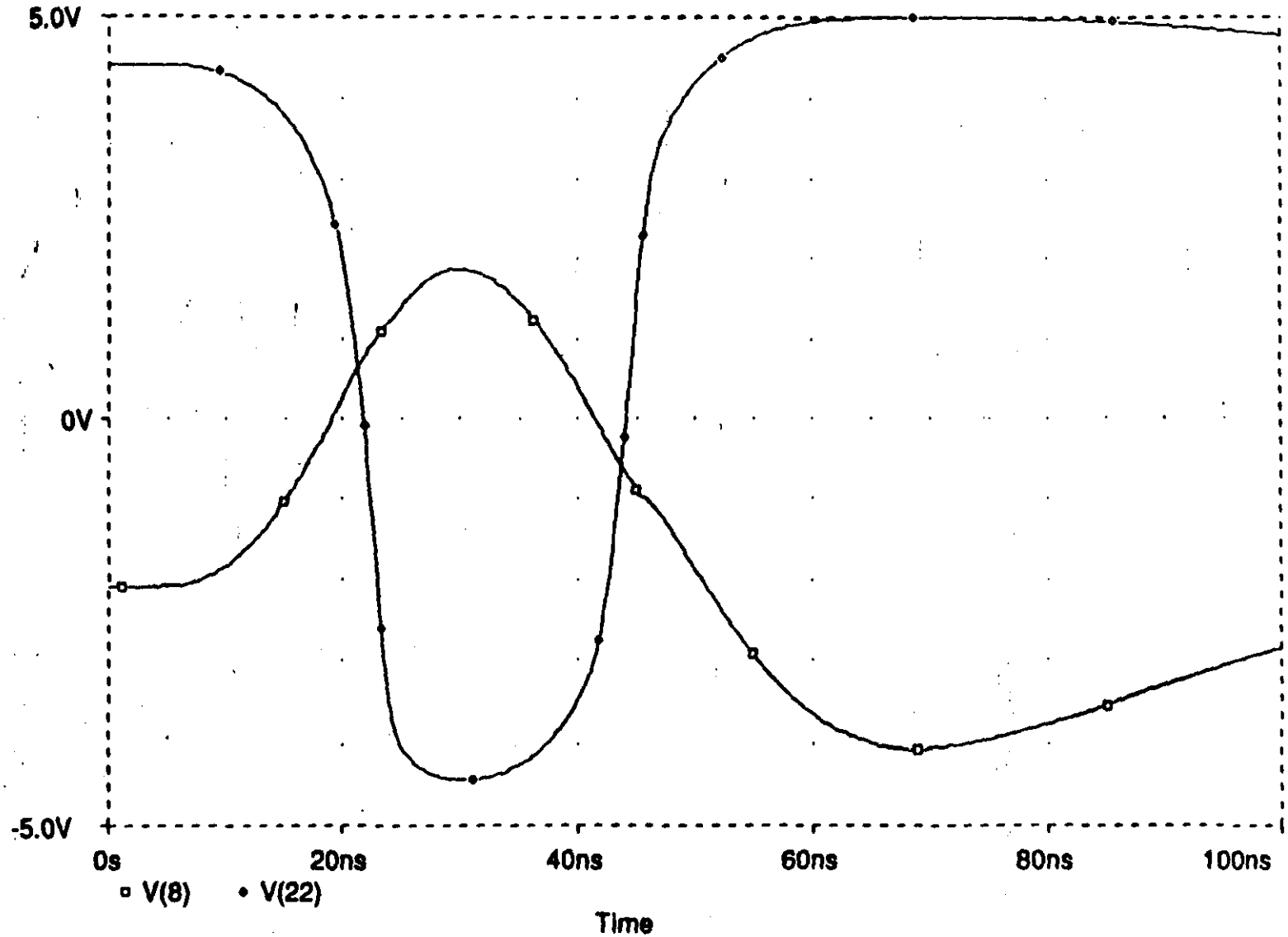


Ø.1 V In

comp1 RLW 1/3/93

Date/Time run: 01/03/93 18:31:44

Temperature: 25.0



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Presentation by:

Gary Liu

FPGA Approach for GEM Muon Trigger

G. Liu

Advantages:

* Flexible —
  The whole configuration can be down loaded at runtime. (xilinx)

* Easy to design —
  Schematics capture, Auto-placement Aute-routing, ability to test part of the circuit before finish.

* Price dropping 50% a year, may be very low cost at the Time of installation

Disadvantages:

* Not as fast as custom ICs and Gate Arrays.

* Not as dense as custom ICs and Gate Arrays

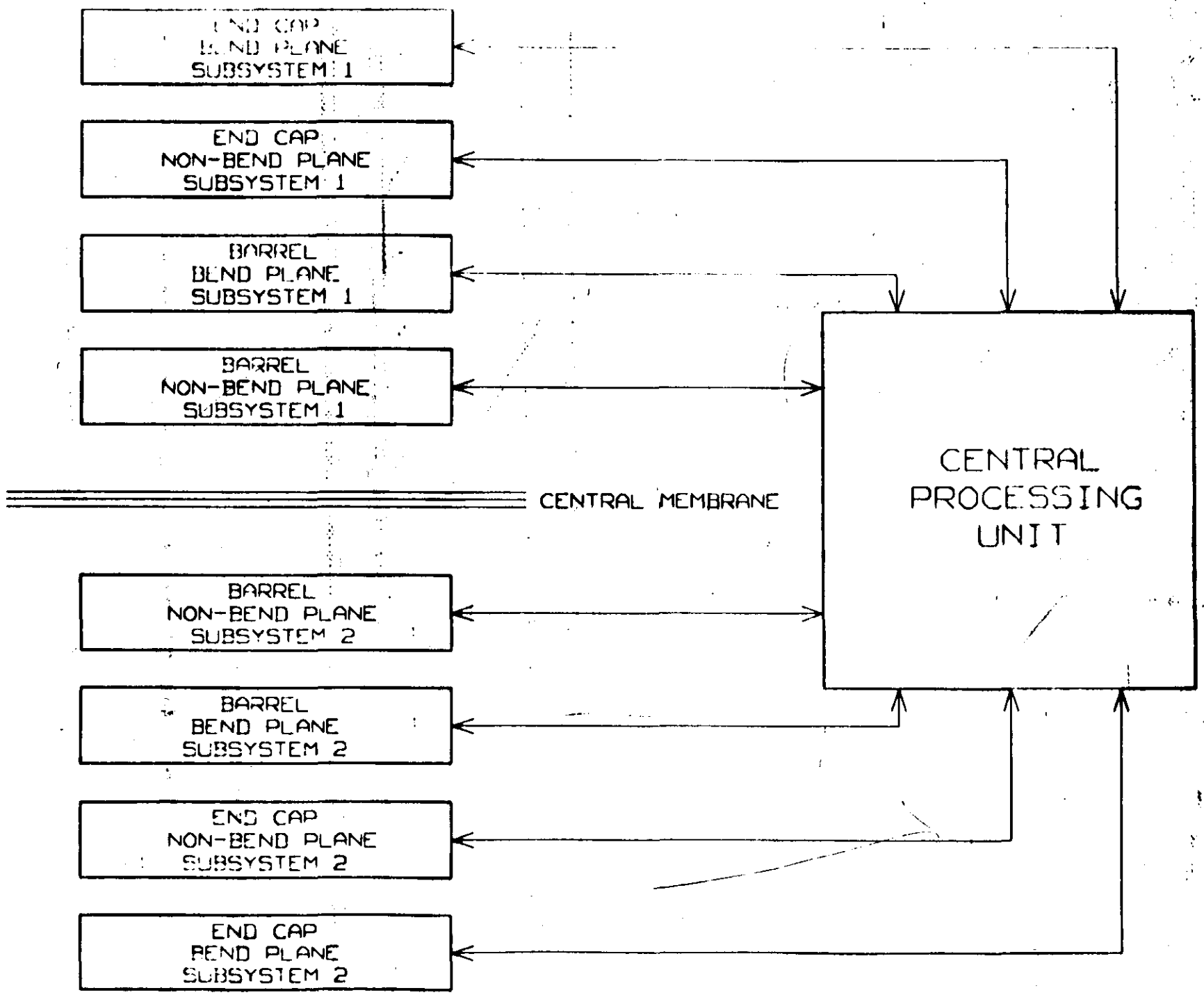

END CAP
BEND PLANE
SUBSYSTEM 1
END CAP
NON-BEND PLANE
SUBSYSTEM 1
BARREL
BEND PLANE
SUBSYSTEM 1
BARREL
NON-BEND PLANE
SUBSYSTEM 1
CENTRAL MEMBRANE
BARREL
NON-BEND PLANE
SUBSYSTEM 2
BARREL
BEND PLANE
SUBSYSTEM 2
END CAP
NON-BEND PLANE
SUBSYSTEM 2
END CAP
BEND PLANE
SUBSYSTEM 2
CENTRAL
PROCESSING
UNIT
114

FIG. 1

Two Questions:

1) Do we need local direction (P_T) measurement for the trigger?

→ need Monte Carlo study.

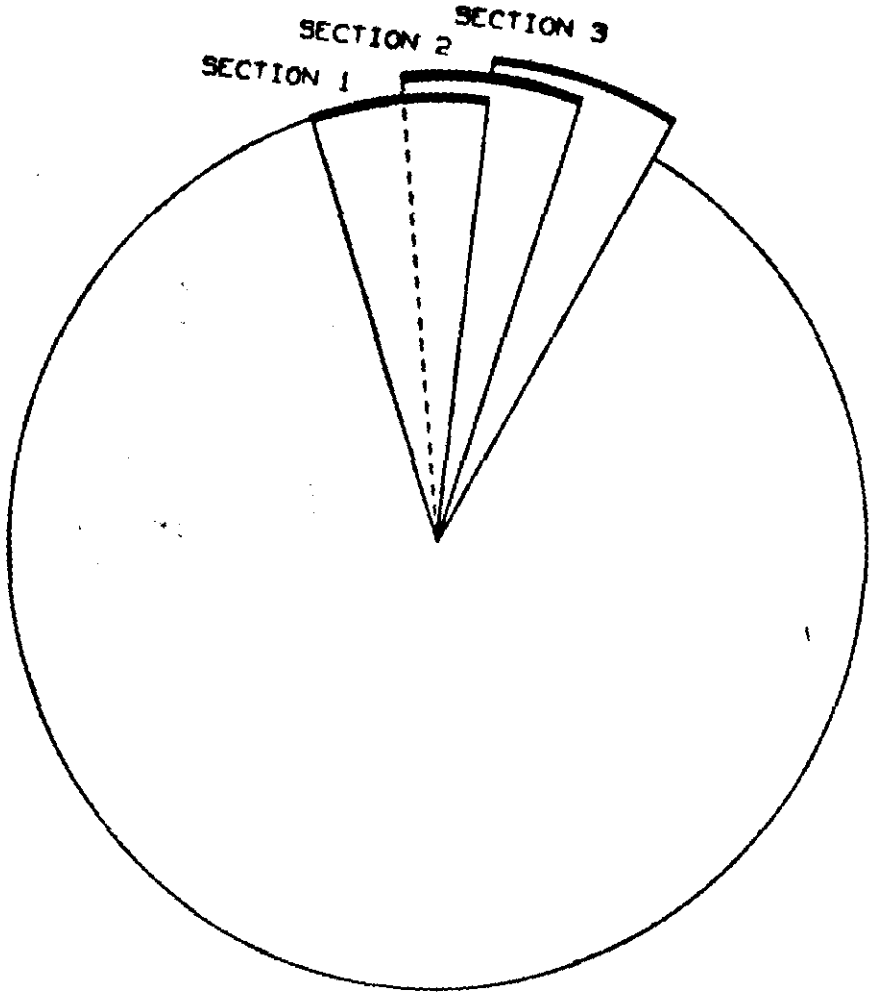
→ Unless monte carlo and other calculation shows that we <u>ABSOLUTELY</u> do not need local P_T measurement, we should put it in.

2) Should we encode <u>HITS</u> or fully pipeline the signal until a <u>TRACK</u> is found?

Encoding hits: Save a few wires
→ multiple hit problem,
→ need local buffer,
→ need time tag,
→ dead time
→ Only work with low rate
...

Fully pipeline: → need more gates and wires
→ simple, straight forward.
→ Cannot use CAM

ACH SECTION IS 12.6 DEGREES,
ROTATED 6 DEGREES FROM
PREVIOUS SECTION



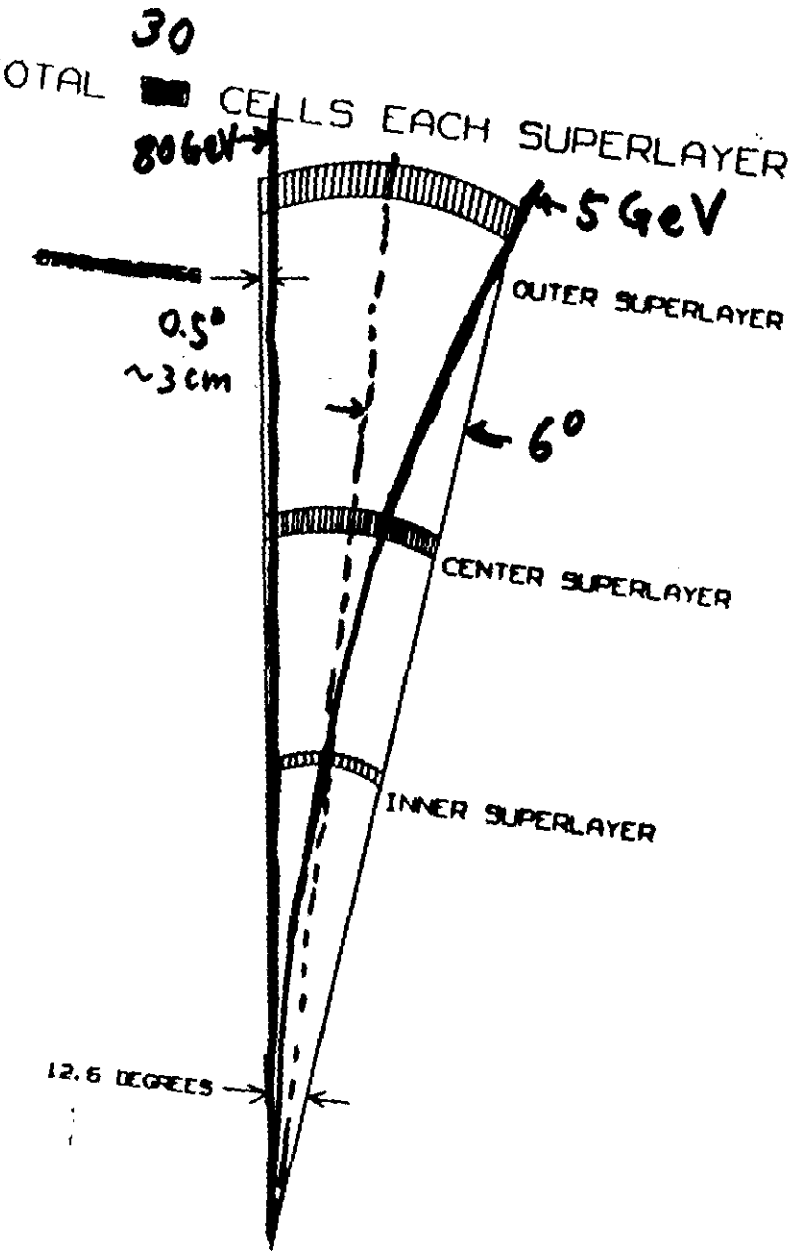
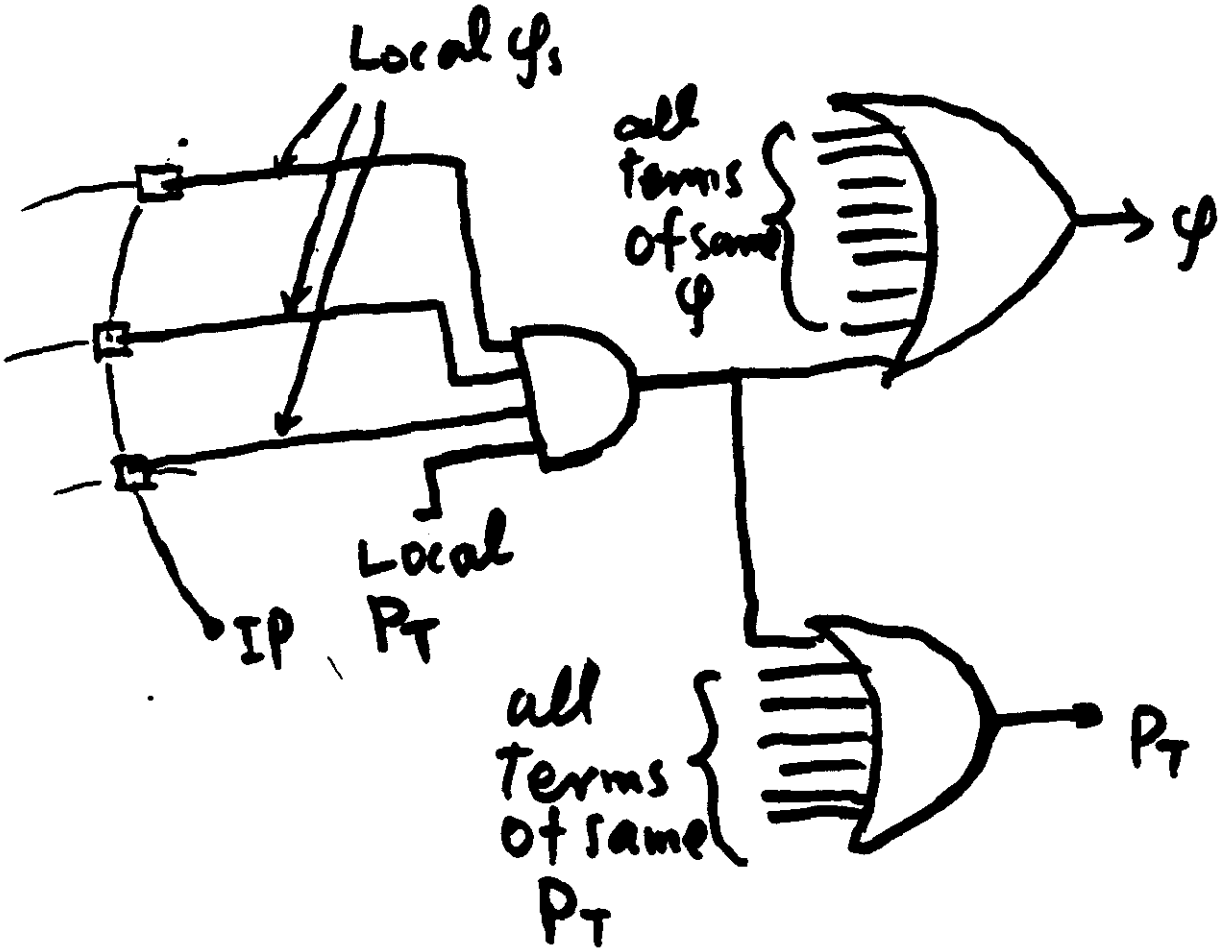


FIG. 2

Coincidence between superlayers



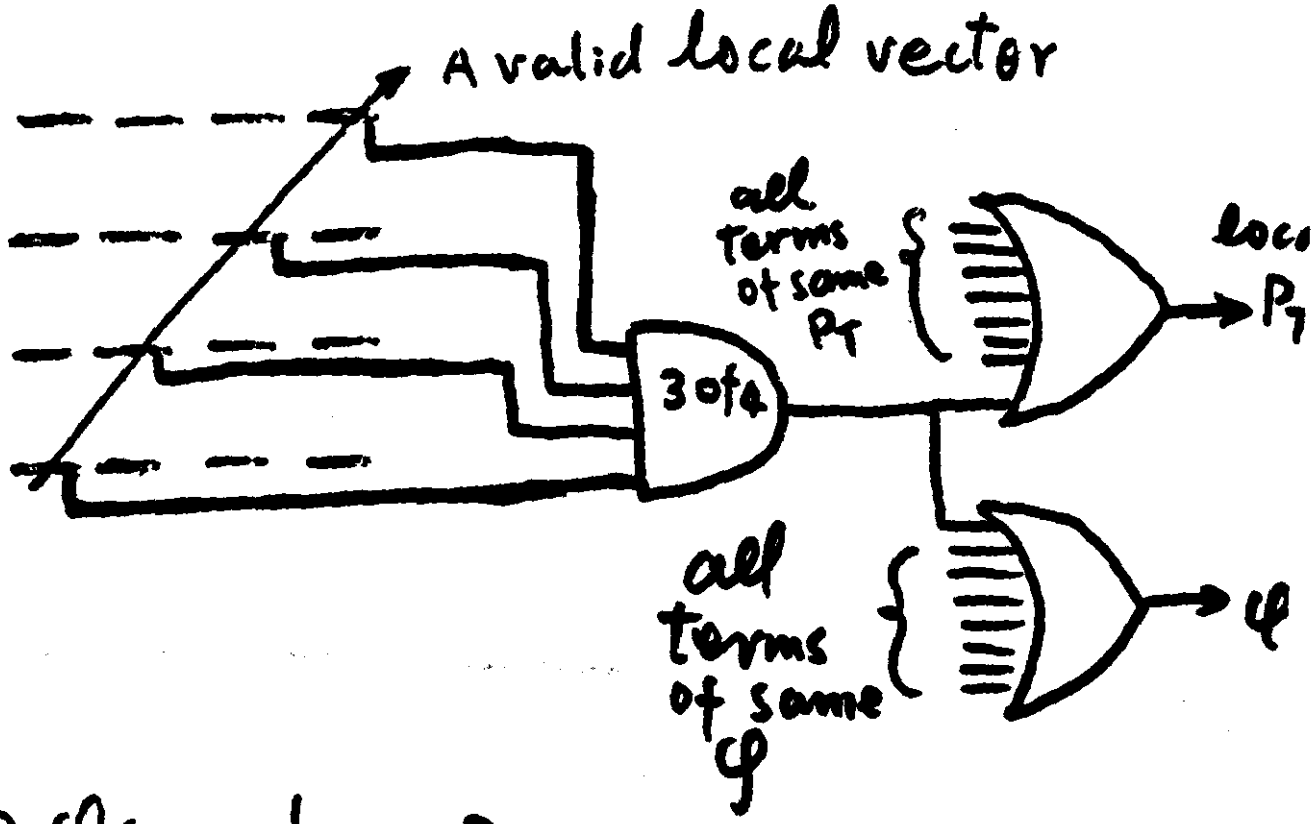
require Local P_T to agree with P_T measured with segita.

store: 30 φs and 30 P_Ts Each section

output: "Alert" (depending on physics. e.g. Alert = P_T > 20GeV
Data containing coded φ and P_T
to be released on "Request"

Local Coincidence

A local vector measurement is a P_T measurement because one can draw only one circle that passes IP and tangent to the local vector.



30 φs and 10 P_Ts → 40 signals

Gate count

Local coincidence FPGA:

need 300 → 150 CLBs

30 { need 10 → 50 CLBs

10 { need 30 → 30 CLBs

total : 230 CLBs

→ Xilinx 4010 (400 CLBs)

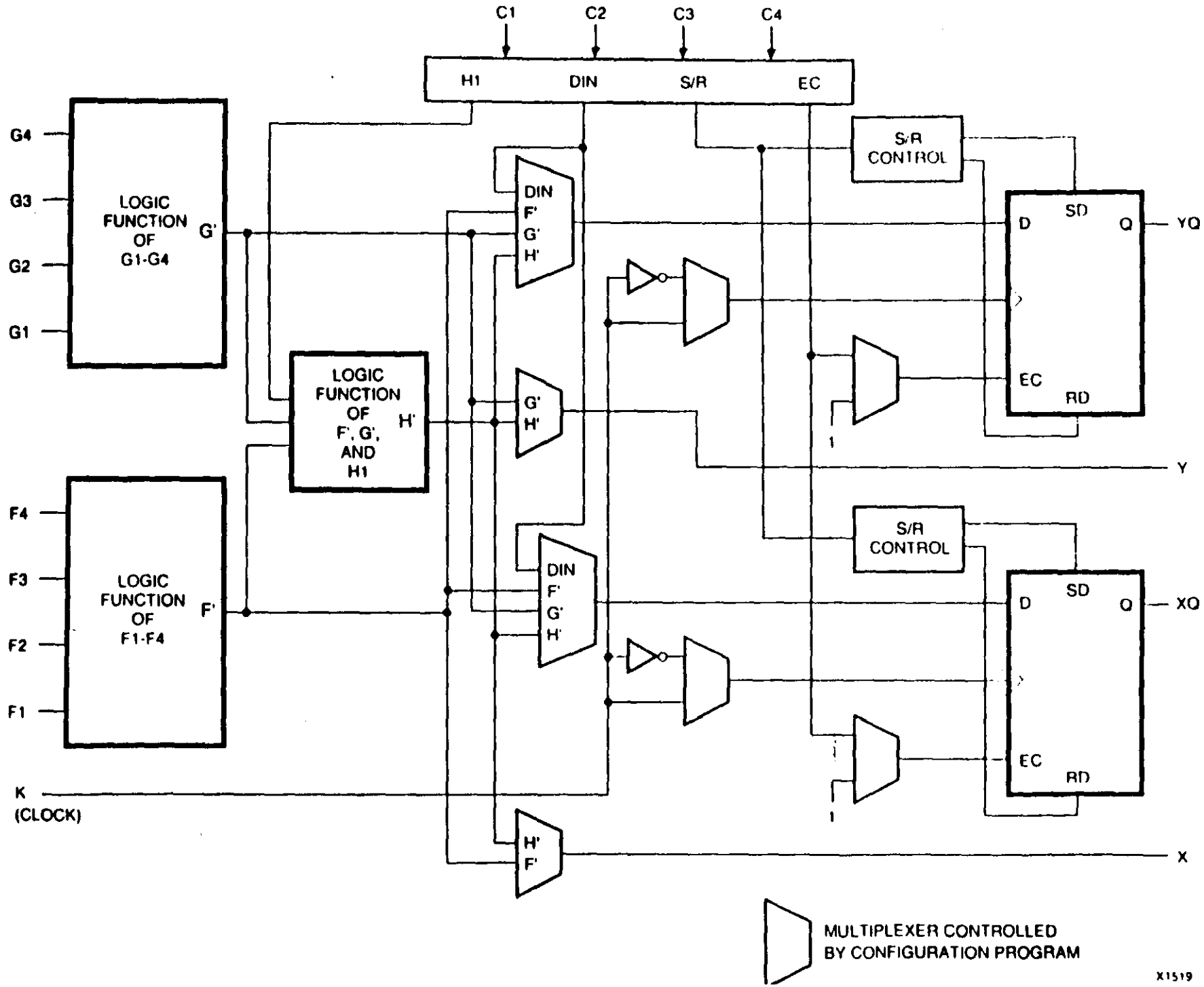
Superlayer coincidence FPGA:

need 800 → 400 CLBs

30 { need 60 → 300 CLBs

total: 700 CLBs

→ Xilinx 4020 (900 CLB


C1
C2
C3
C4
H1
DIN
S/R
EC
G4
G3
G2
G1
LOGIC FUNCTION OF G1-G4
G'
LOGIC FUNCTION OF F', G', AND H1
H'
F4
F3
F2
F1
LOGIC FUNCTION OF F1-F4
F'
K (CLOCK)
DIN F' G' H'
G' H'
DIN F' G' H'
H' F'
S/R CONTROL
S/R CONTROL
D
SD
Q
YQ
EC
RD
1
Y
D
SD
Q
XQ
EC
RD
1
X
MULTIPLEXER CONTROLLED BY CONFIGURATION PROGRAM
X1519

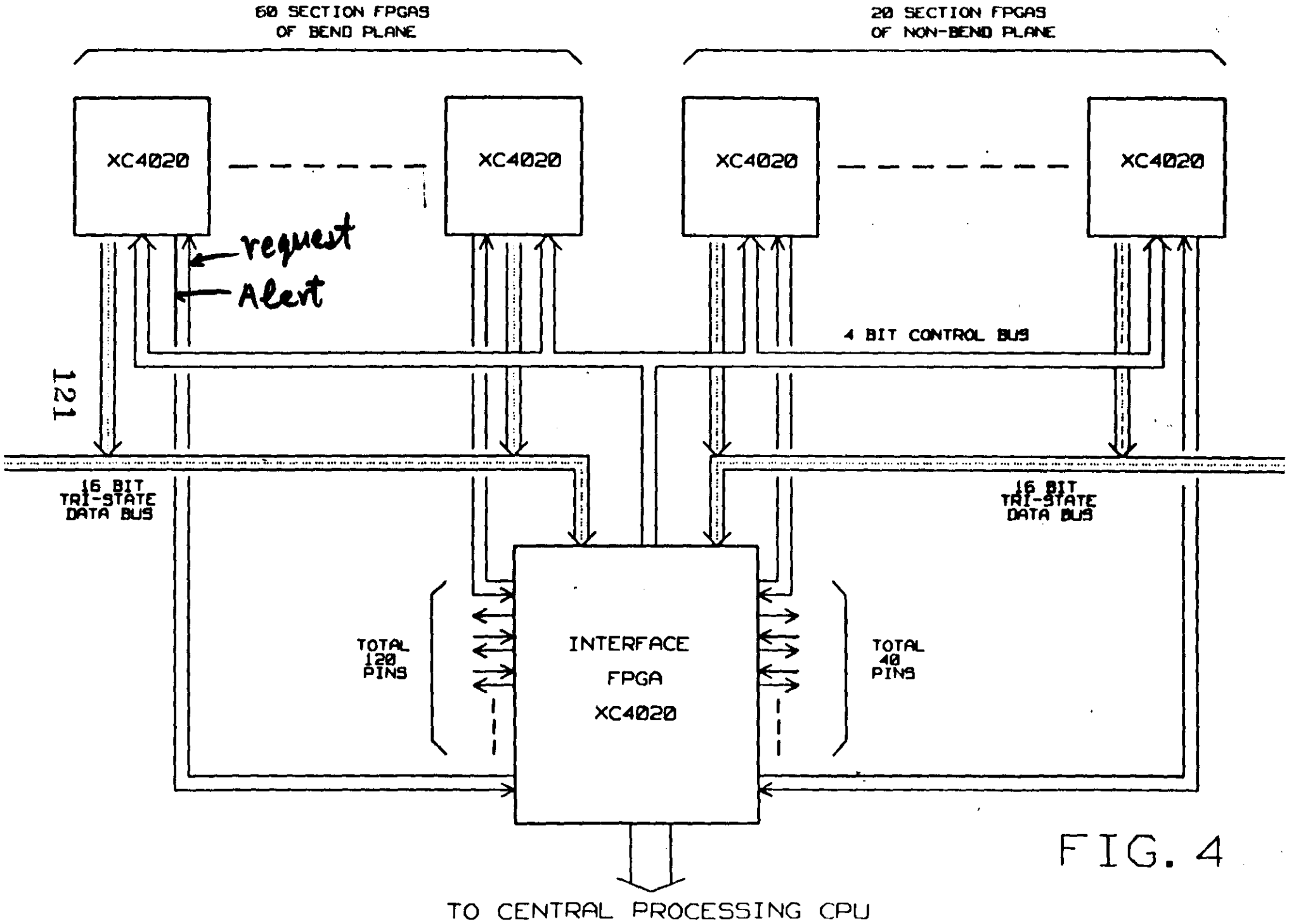

60 SECTION FPGAS
OF BEND PLANE
20 SECTION FPGAS
OF NON-BEND PLANE
XC4020
XC4020
XC4020
XC4020
request
Alert
4 BIT CONTROL BUS
121
16 BIT
TRI-STATE
DATA BUS
16 BIT
TRI-STATE
DATA BUS
TOTAL
120
PINS
INTERFACE
FPGA
XC4020
TOTAL
40
PINS
TO CENTRAL PROCESSING CPU

FIG. 4

FPGA Count

$\frac{1}{2}$ of Barrel Bend plane:

$$4 \times 60 \rightarrow 240$$

$\frac{1}{2}$ of Barrel nonbend plane:

$$2 \times 20 \rightarrow 40$$

Total <u>560</u> for whole Barrel