GEM TN-92-174

Electronics Meeting-SSCL

September 4, 1992

Abstract:

Agenda and presentations of the GEM Electronics Meeting held at the SSCL on September 4, 1992. Agenda items are: Preliminary Remarks & Meeting Schedule; Short Reports: Digital Discriminator, Datawave Update, Pipeline ADC's, SDC Calorimeter Review; Status Reports: Calorimeter Readout, IPC Readout; DAQ Design for GEM; and R&D Plan.

GEM Electronics Meeting Agenda

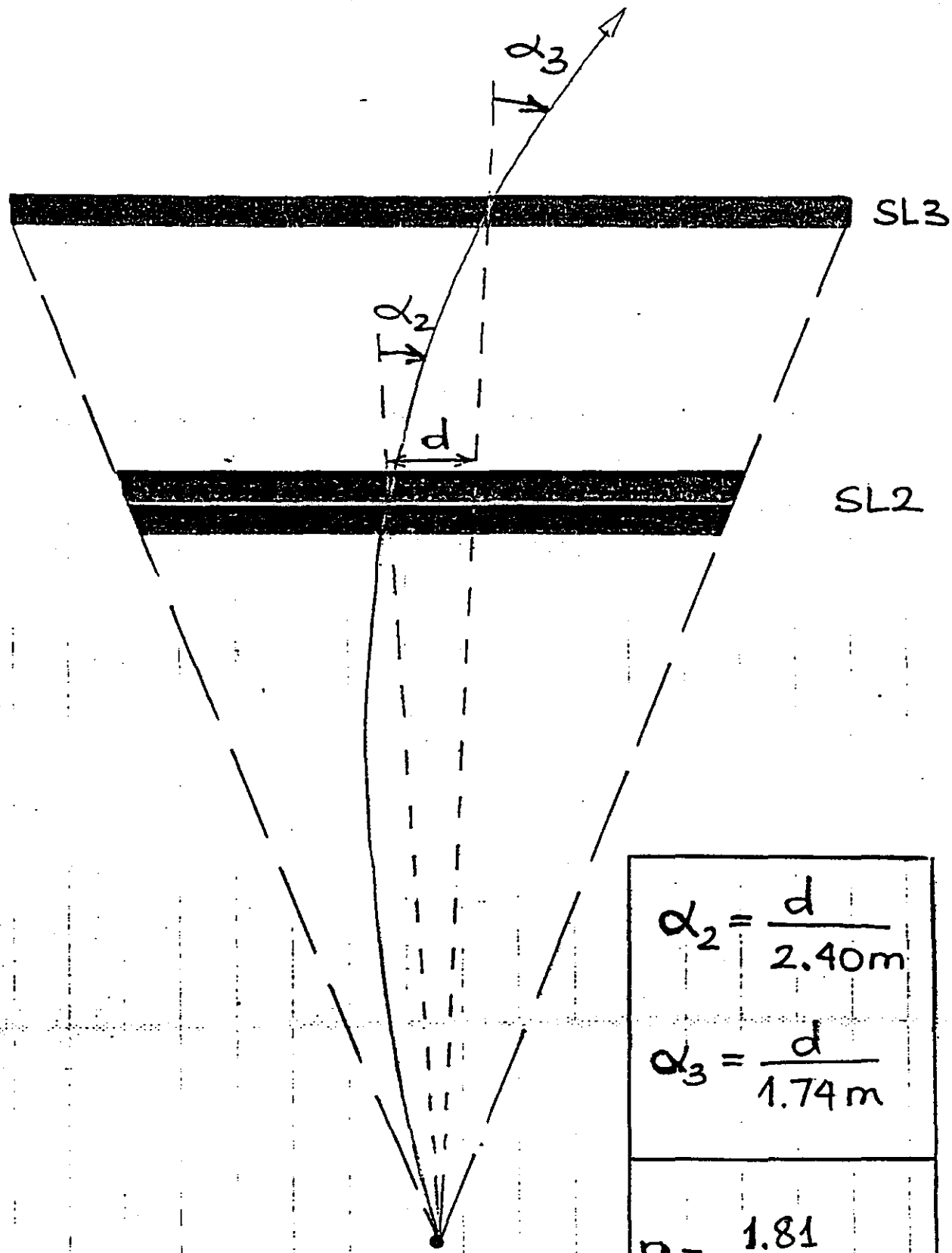
Friday Sept. 4, 1992 (TODAY)

12:00 PM	Preliminary Remarks & Meeting Schedules			
12:30 PM	Short Reports			
	Digital Discriminator	Prebys	15 min	
	Datawave Update	Crosetto	10 min	1:05
	Pipeline ADC's	Liu	15 min	1:10
	SDC Calorimeter Review	Marlow	10 min	
1:30 PM	Status Reports			
	Calorimeter Readout	Parsons	20 min	
	IPC Readout	Musser/Britton	20 min	
2:15 PM	DAQ Design for GEM	Dorenbosch et al	45 min	
3:15 PM	R&D Plan	Discussion		

September 2, 1992

A.Korytov, L.Osborne (M.I.T.)
R.Sumner (LeCroy)

MOMENTUM and TIME TRIGGER based on LSDT's



$$\alpha_2 = \frac{d}{2.40\,m}$$

$$\alpha_3 = \frac{d}{1.74\,m}$$

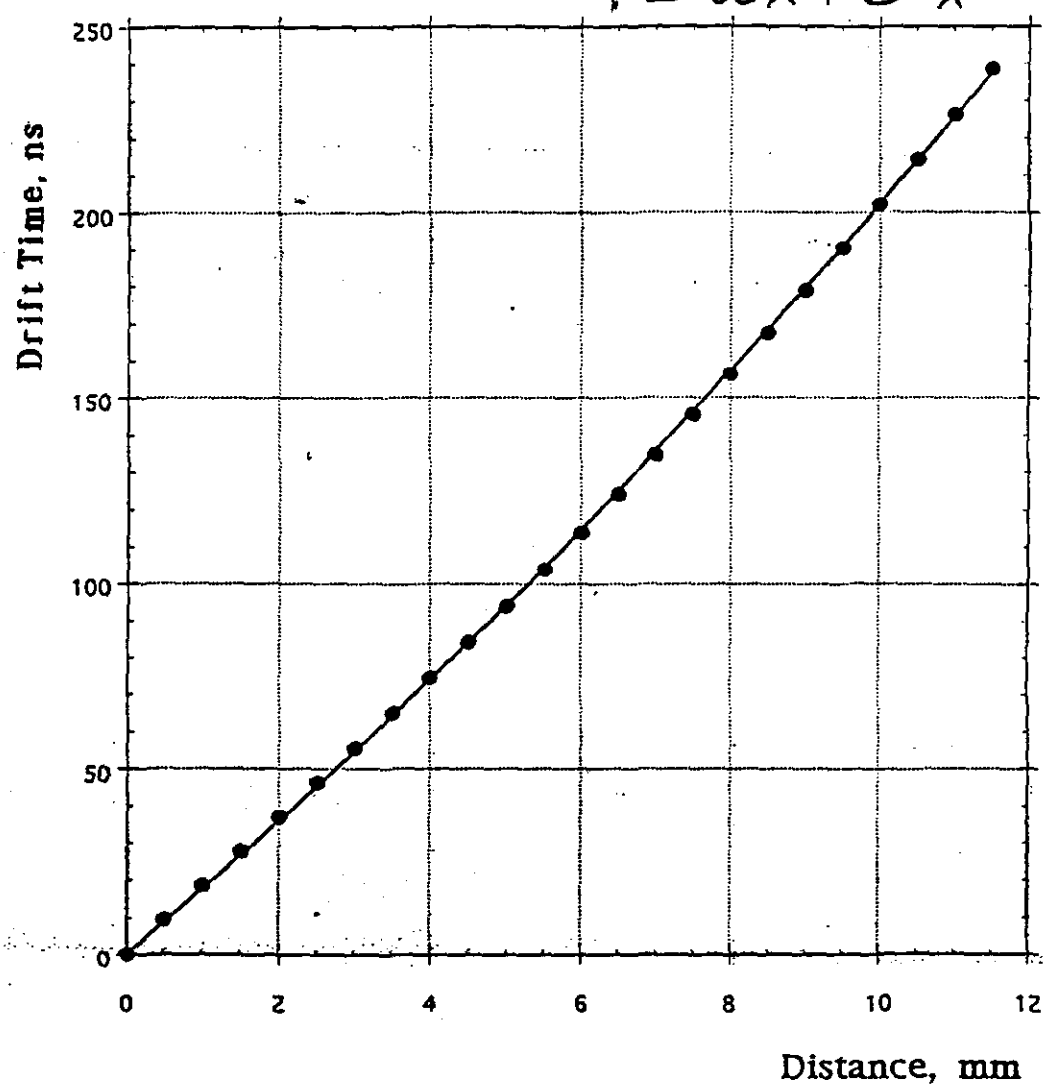
$$p = \frac{1.81}{d\,(m)}$$

$\alpha_2 = 4.4°$ for $p = 10$ GeV/c

y = m1*M0 + m2*M0*M0		
	Value	Error
m1	17.357073062	0.094725
m2	0.28546071821	0.0104131
Chisq	13.306709135	NA
R	0.99994534341	NA

T=a*X + b*X^2
(Points are calculated
from accurate fit of LASER DATA),
Ar+iB =25+75

$$T = a \cdot x + b \cdot x^2$$



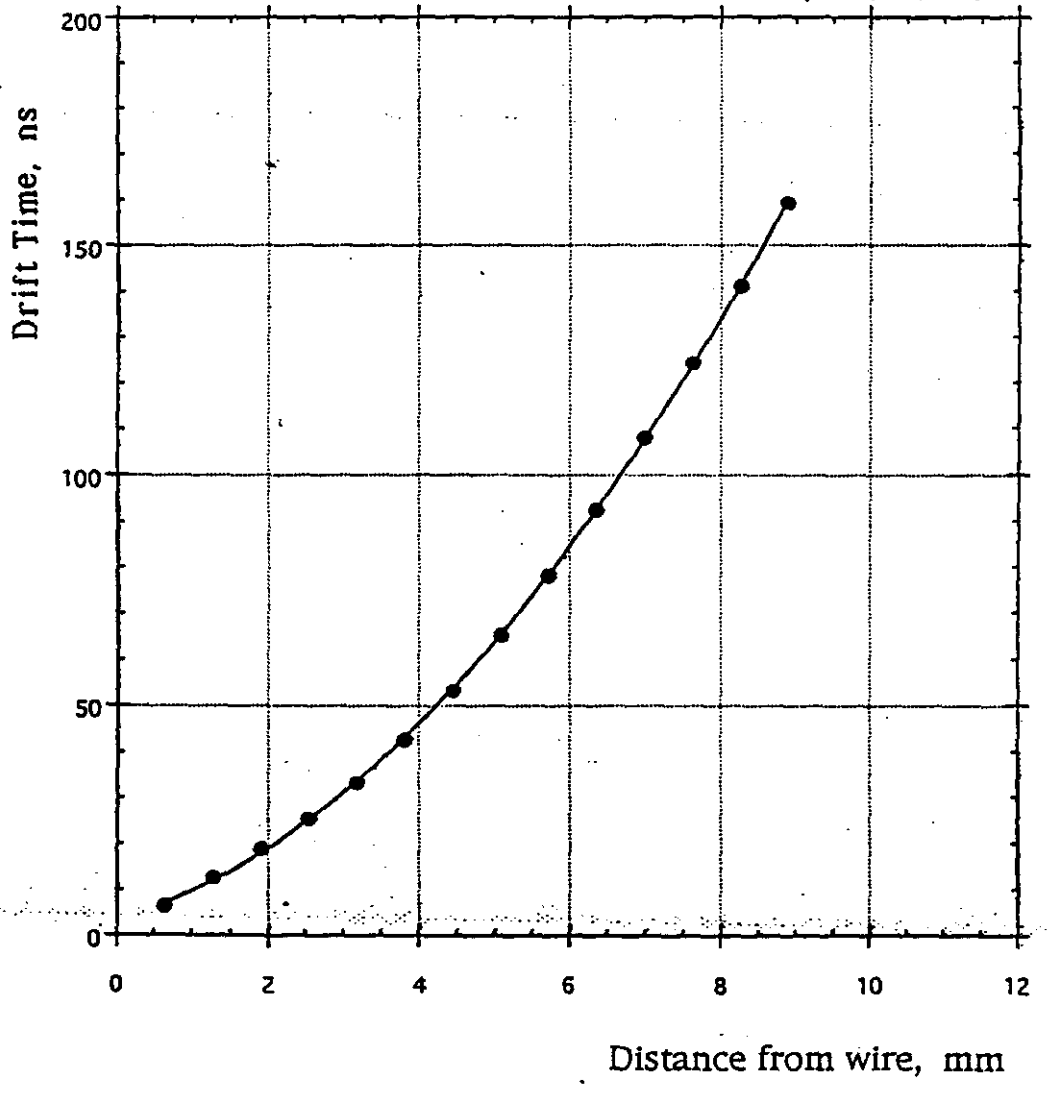
y = m1+m2*M0 + m3*M0*M0		
	Value	Error
m1	3.3417585497	0.484641
m2	5.031063318	0.23408
m3	1.4116950994	0.0239047
Chisq	2.9760939244	NA
R	0.99995388072	NA

$CF_4 + CO_2 + C_4H_{10} = 69 + 20 + 11$

U = 5.4 kV

Laser Data

$T = a \cdot x + b \cdot x^2$

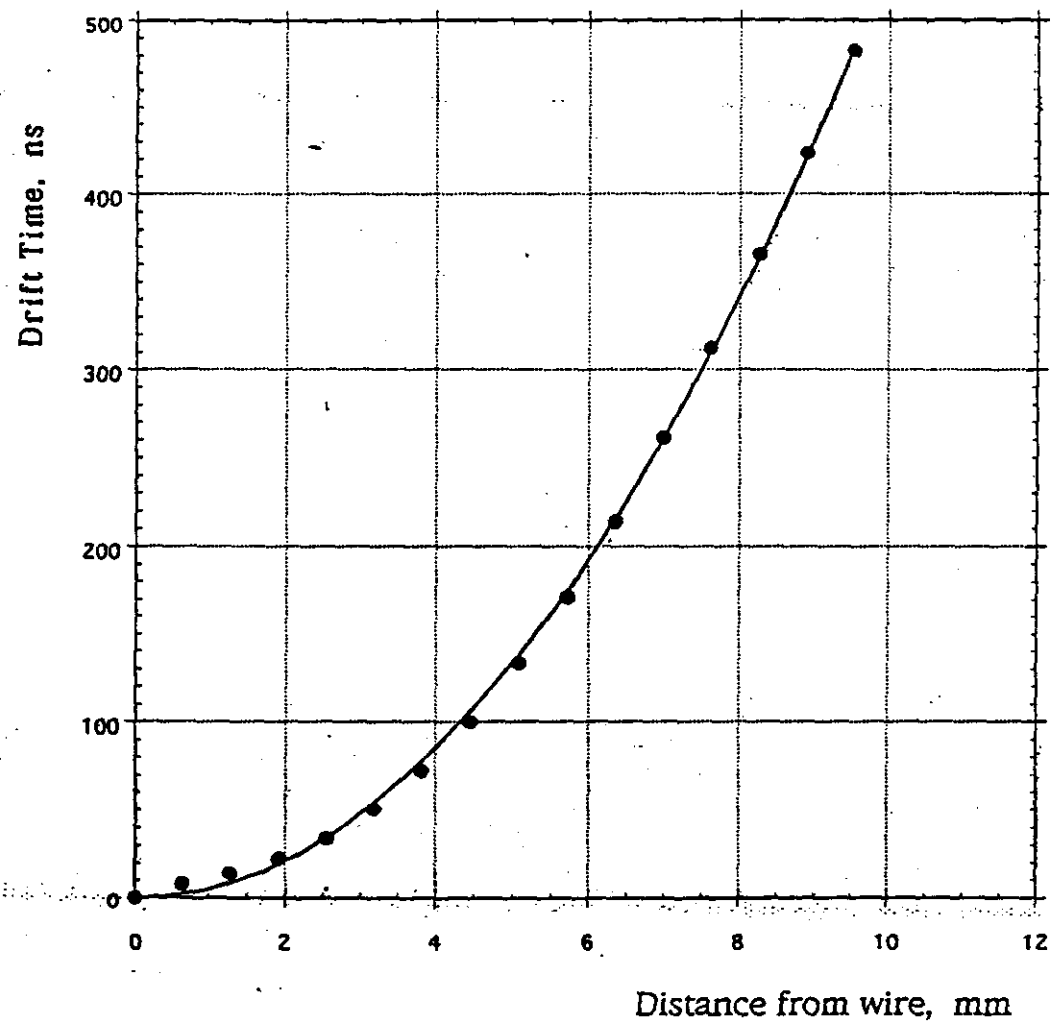


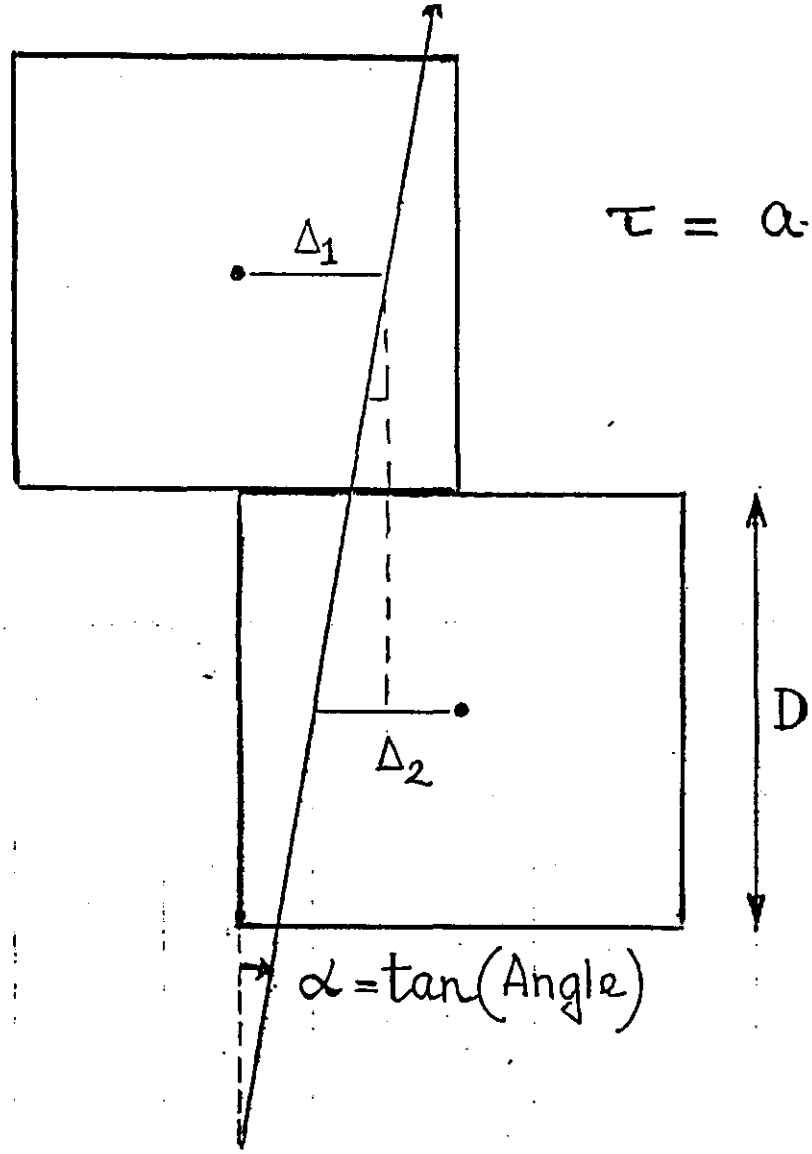
T=b*x^2		
	Value	Error
b	5.3277617937	0.0214464
Chisq	199.89911477	NA
R	0.99973685403	NA

$$T = b \cdot x^2$$

$Ar+CO_2+C_4H_{10}$ = 2.5 + 88 + 9.5

Laser Data

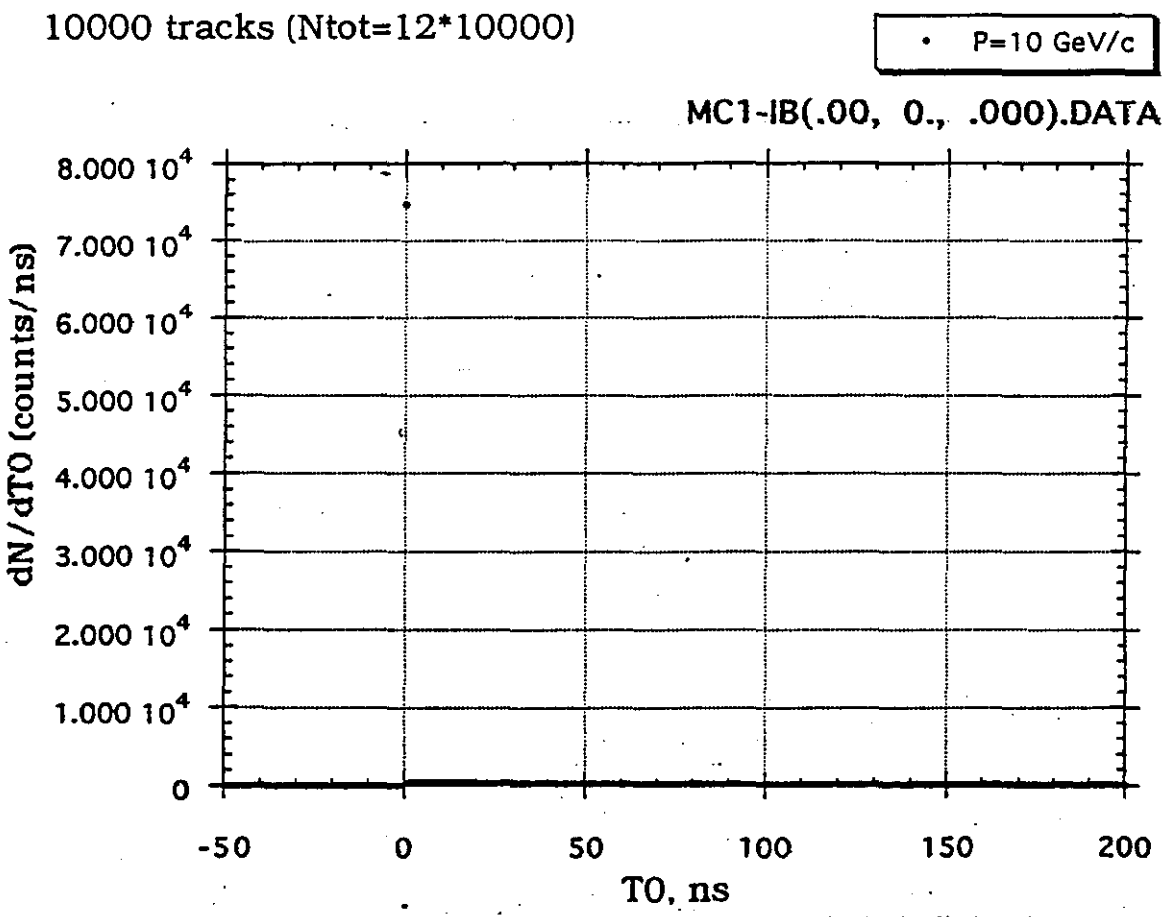




$$\tau = a \cdot \Delta + b \cdot \Delta^2$$

$$T_0 = \frac{T_1 + T_2}{2} - \frac{a \cdot C_0}{2} - \frac{b}{4}\left(C_0^2 + \frac{(\Delta T)^2}{(a + bC_0)^2}\right)$$

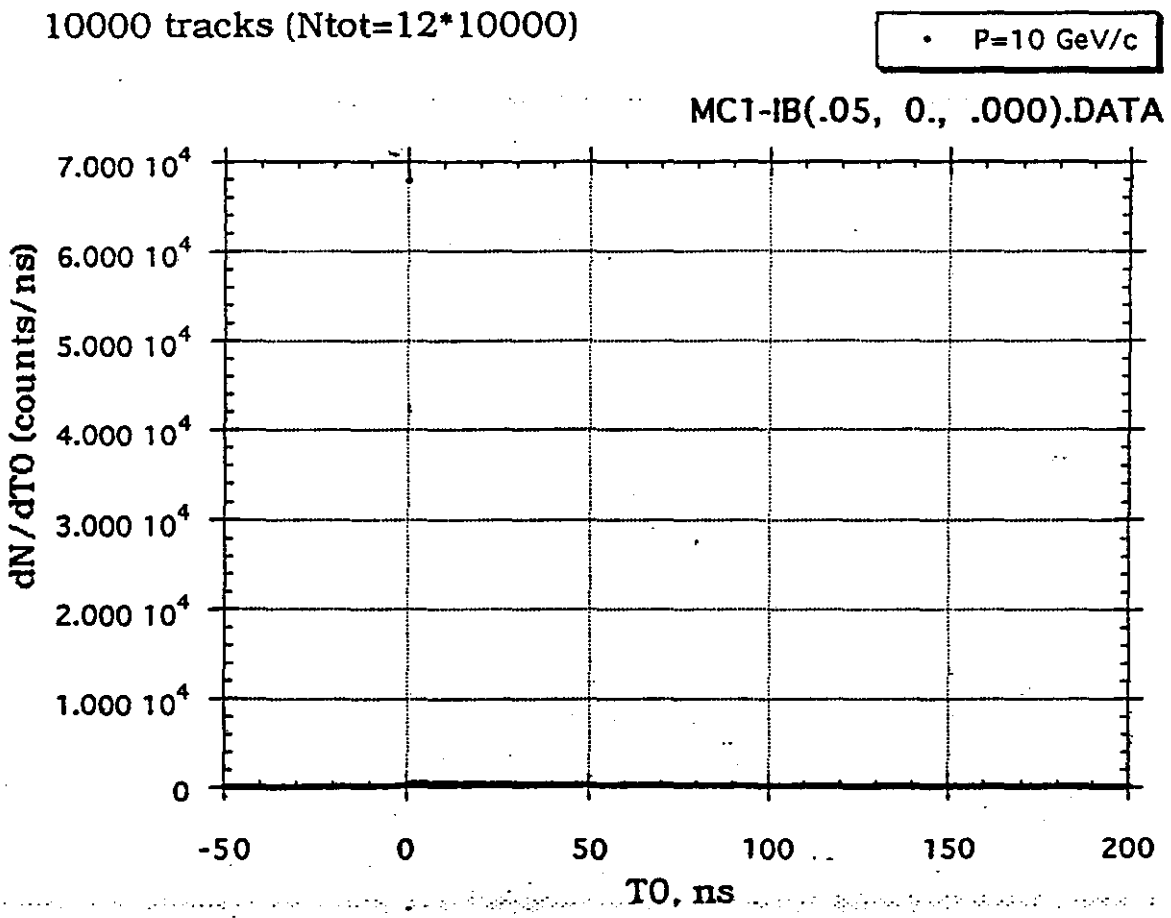
$$C_0 = \frac{D}{2} + \alpha \cdot D$$


10000 tracks (Ntot=12*10000)
P=10 GeV/c
MC1-IB(.00, 0., .000).DATA
8.000 10^4
7.000 10^4
6.000 10^4
5.000 10^4
4.000 10^4
3.000 10^4
2.000 10^4
1.000 10^4
0
dN/dT0 (counts/ns)
-50
0
50
100
150
200
T0, ns

a= 17.35707 b= 0.2854607
KEY=1
eps=.000 Terror(ns)=0.0 Aerror(rad)=.000

P= 10. GeV:	Nyes-Nno-Nwrong=	9998	0	2
P= 20. GeV:	Nyes-Nno-Nwrong=	10000	0	0
40. GeV:	Nyes-Nno-Nwrong=	10000	0	0
= 80. GeV:	Nyes-Nno-Nwrong=	9998	0	2
P=160. GeV:	Nyes-Nno-Nwrong=	9999	0	1
P=320. GeV:	Nyes-Nno-Nwrong=	10000	0	0

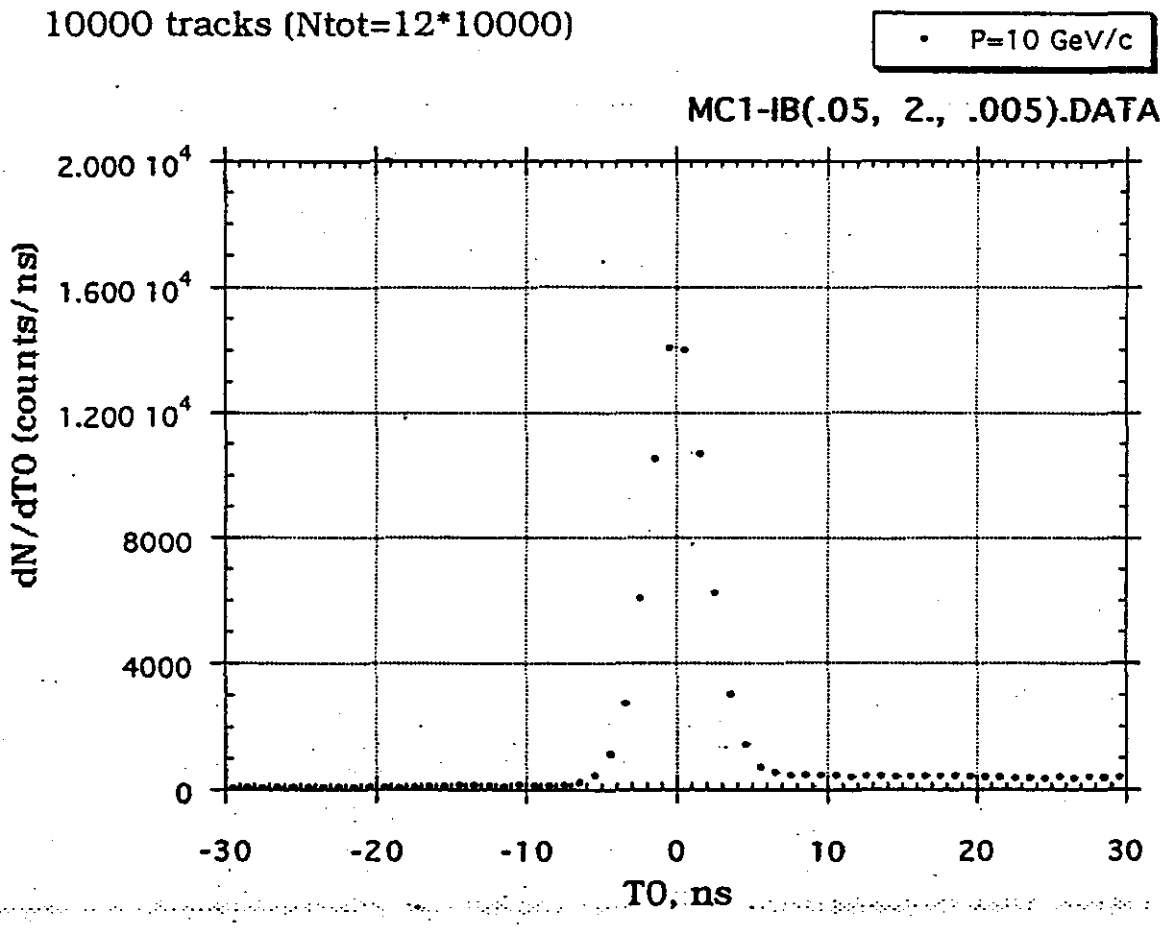
Coincidence Level	p=10	=20	=40	=80	=160	=320
0	0	0	0	0	0	0
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4	0	0	0	0	0	0
5	0	0	0	0	0	0
6	796	1003	1162	1199	1239	1245
7	2293	2593	2639	2642	2656	2716
8	5104	4673	4596	4510	4449	4417
9	1640	1565	1426	1468	1444	1447
10	165	162	171	176	208	166
11	2	2	5	5	4	7
12	0	2	1	0	0	2


10000 tracks (Ntot=12*10000)
P=10 GeV/c
MC1-IB(.05, 0., .000).DATA
7.000 10^4
6.000 10^4
5.000 10^4
4.000 10^4
3.000 10^4
2.000 10^4
1.000 10^4
0
dN/dT0 (counts/ns)
-50
0
50
100
150
200
T0, ns

$\varepsilon = 0.05$ / cell (δ-electron production)

$\delta T = 2\,ns$

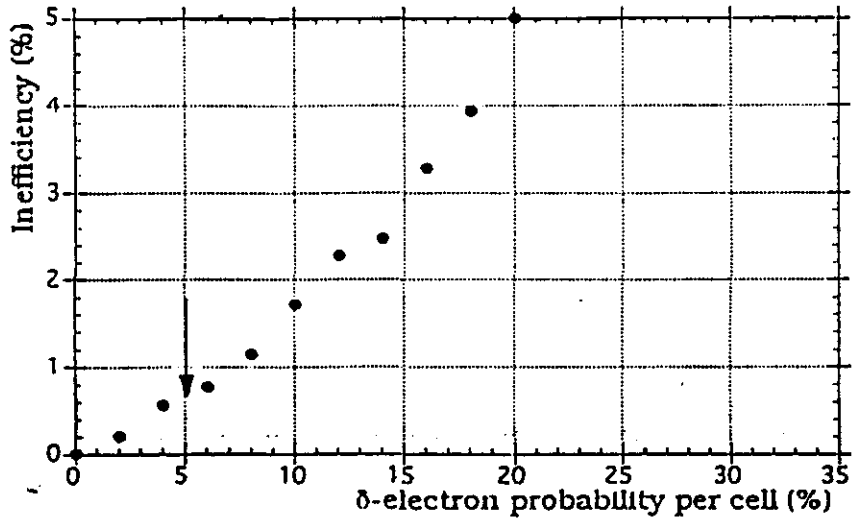
$\delta\alpha = .005$ ($\approx .3°$)

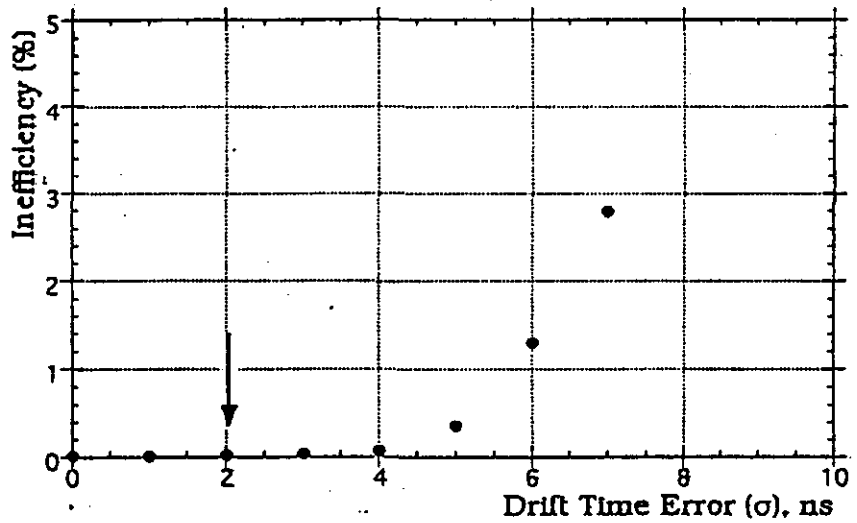


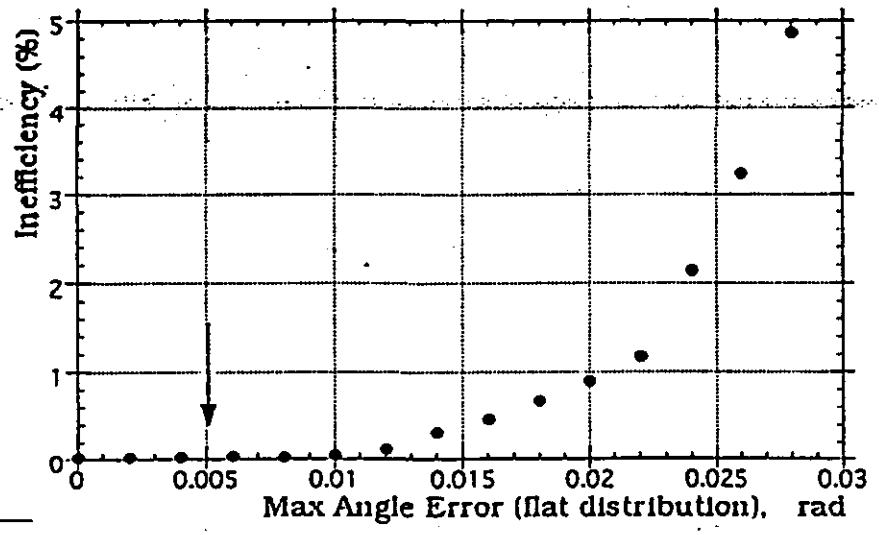
SL2

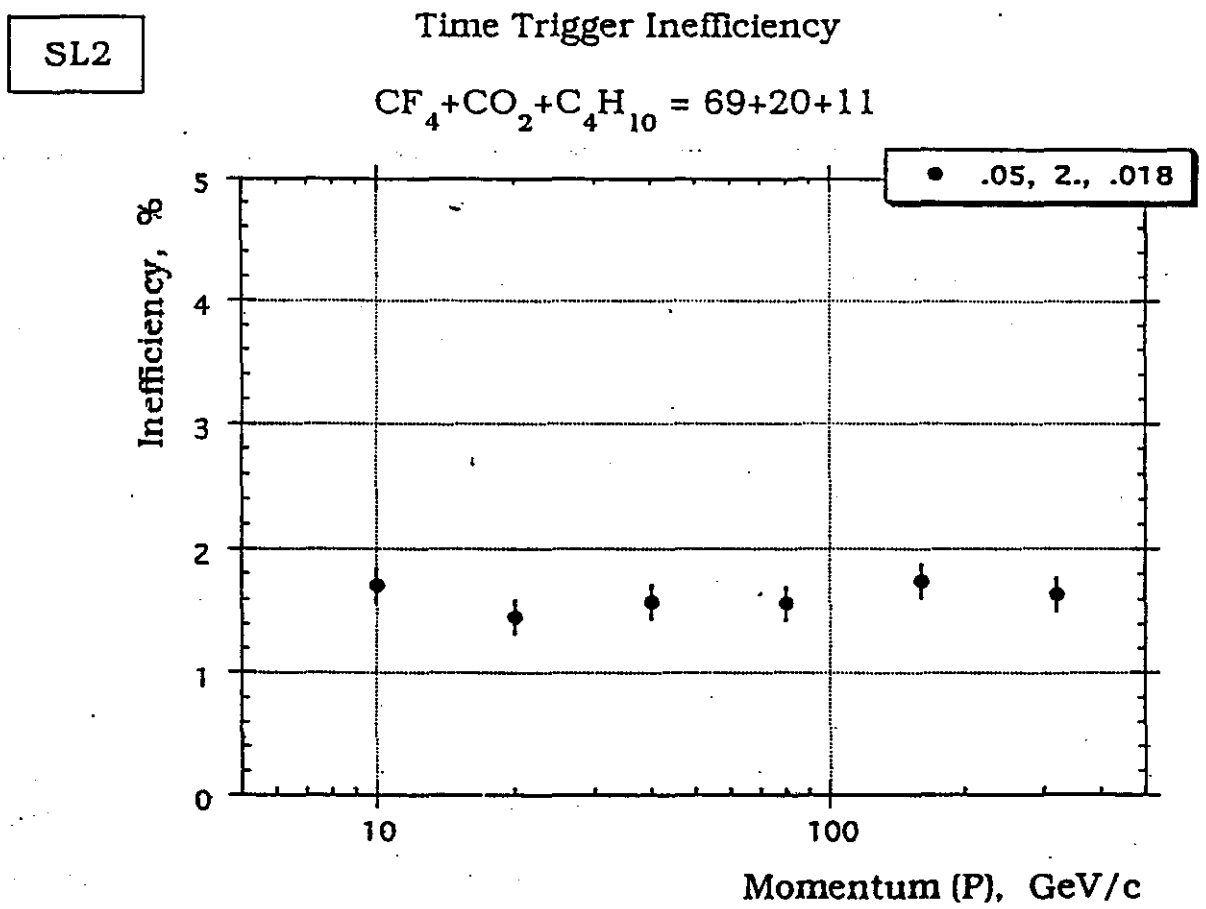
Time Trigger Inefficiency

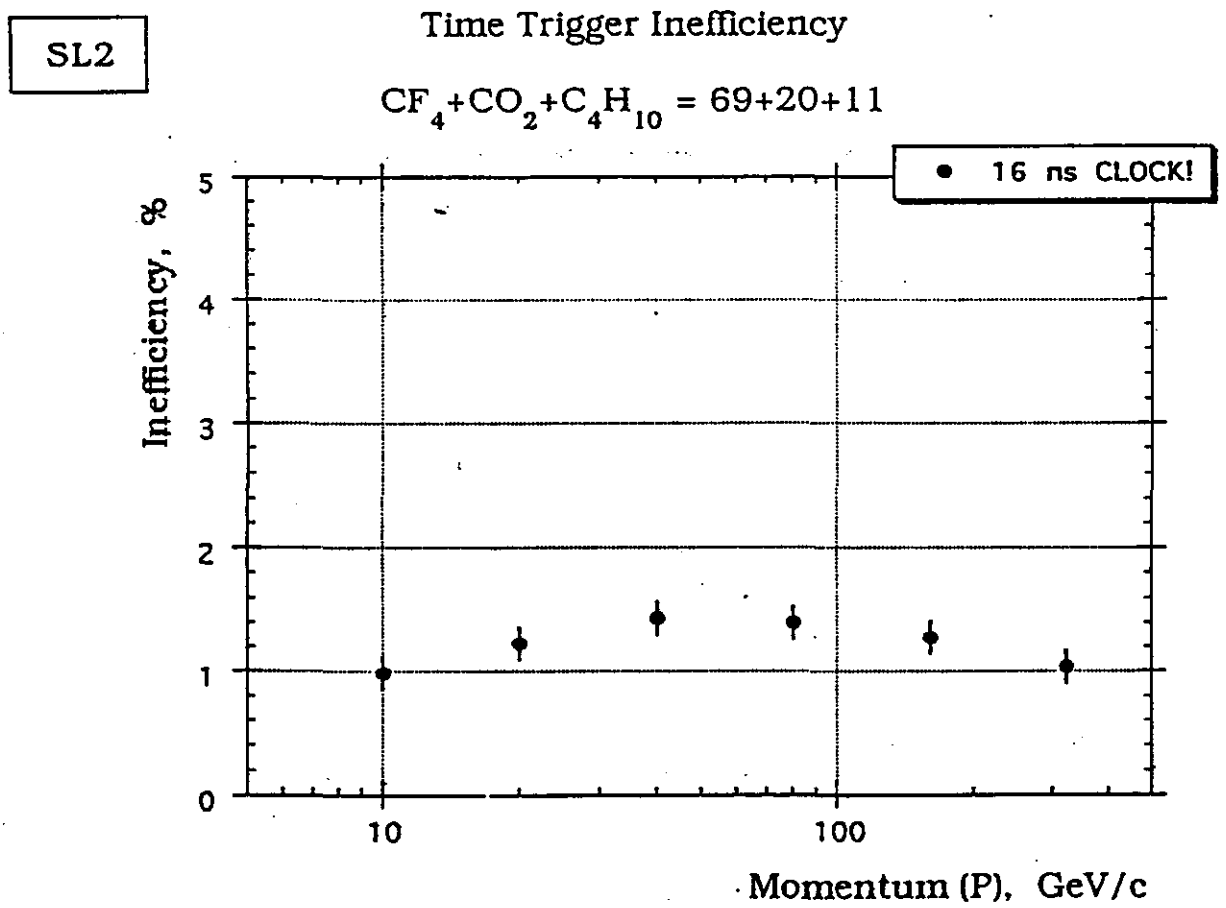
$CF_4+CO_2+C_4H_{10}$ = 69+20+11



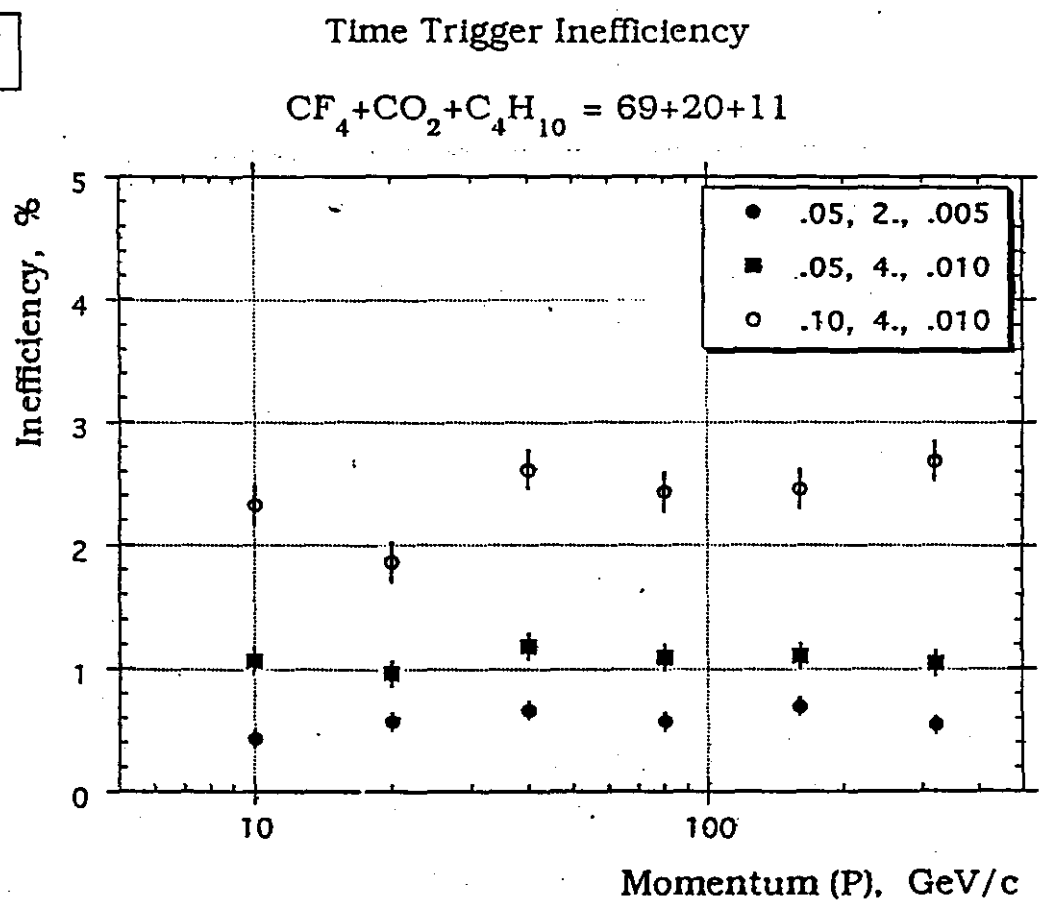





SL2
Time Trigger Inefficiency
$CF_4+CO_2+C_4H_{10}$ = 69+20+11
.05, 2., .018
Inefficiency, %
0
1
2
3
4
5
10
100
Momentum (P), GeV/c


SL2
Time Trigger Inefficiency
$CF_4+CO_2+C_4H_{10}$ = 69+20+11
16 ns CLOCK!
Inefficiency, %
0
1
2
3
4
5
10
100
Momentum (P), GeV/c

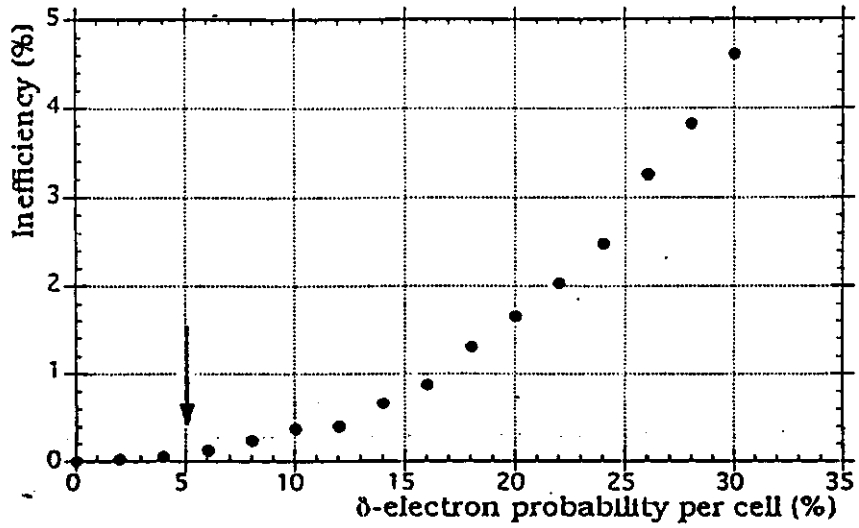
SL2

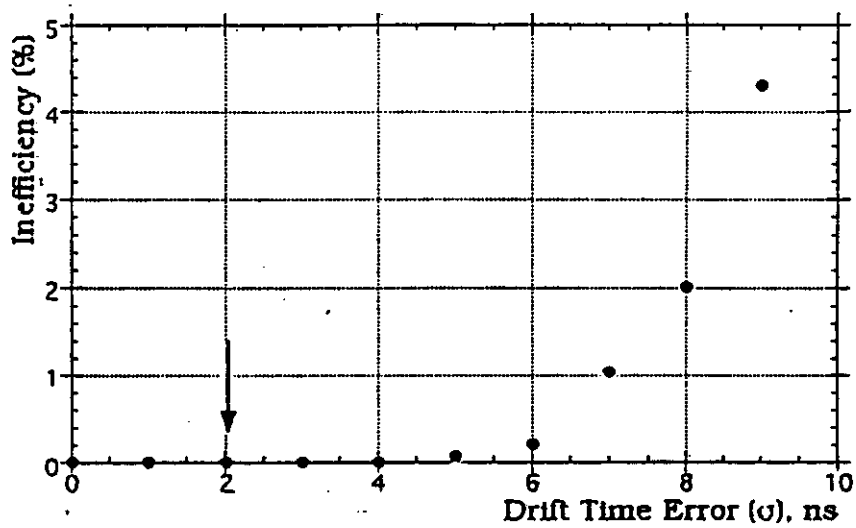

Time Trigger Inefficiency
$CF_4+CO_2+C_4H_{10}$ = 69+20+11
Inefficiency, %
Momentum (P), GeV/c
.05, 2., .005
.05, 4., .010
.10, 4., .010
0
1
2
3
4
5
10
100

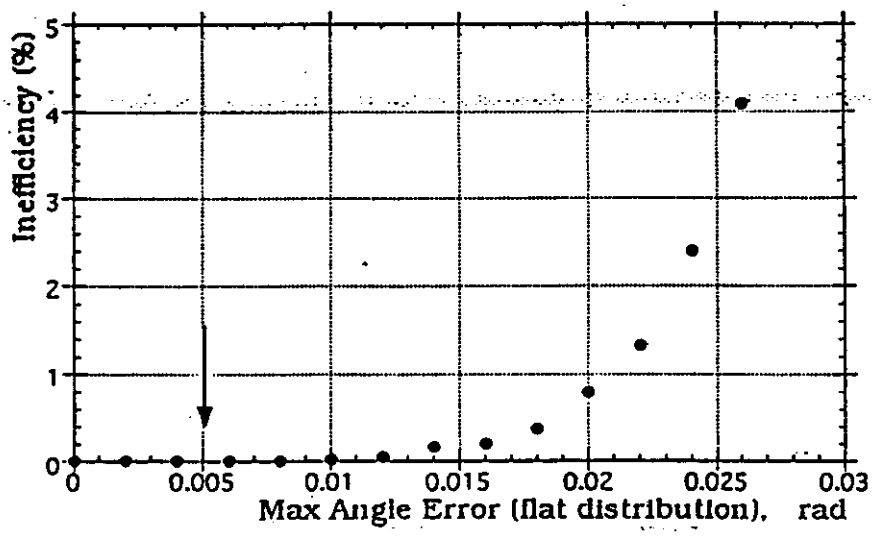
SL2+SL3

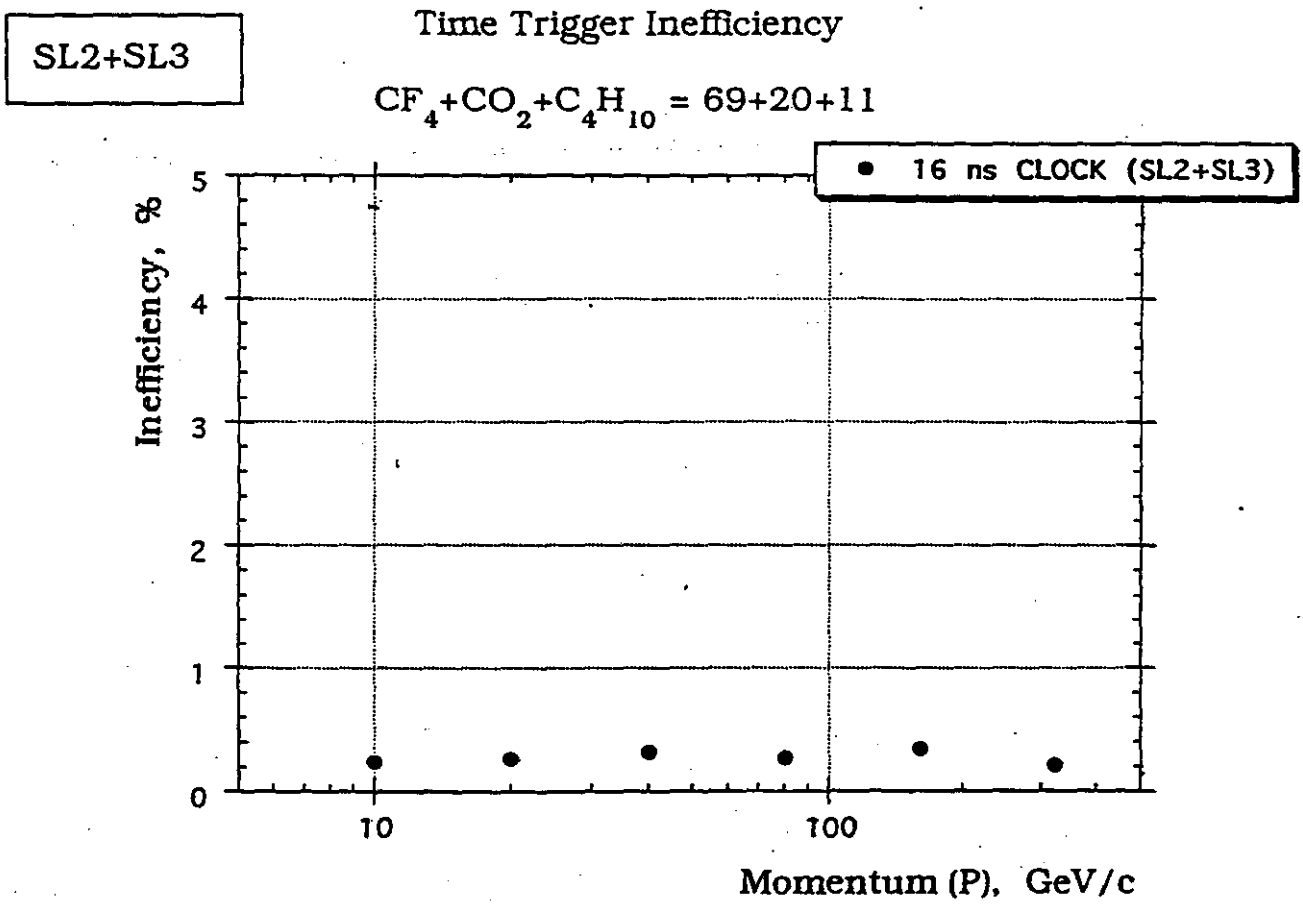
Time Trigger Inefficiency

$CF_4+CO_2+C_4H_{10}$ = 69+20+11







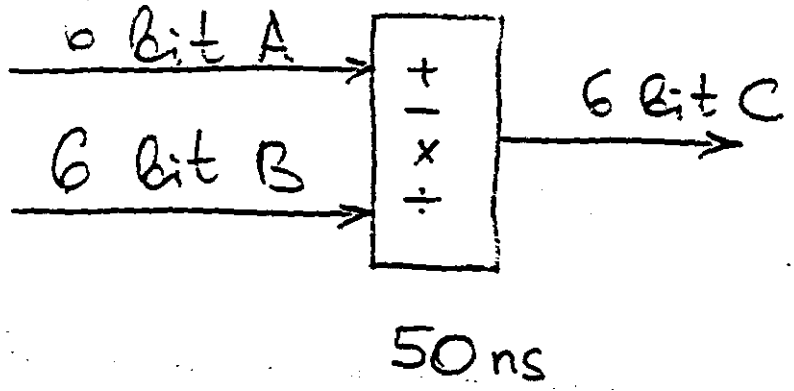

SL2+SL3
Time Trigger Inefficiency
$CF_4+CO_2+C_4H_{10}$ = 69+20+11
16 ns CLOCK (SL2+SL3)
Inefficiency, %
5
4
3
2
1
0
10
100
Momentum (P), GeV/c

$$T_0 = \frac{T_1+T_2}{2} - \frac{a}{2}C_0 - \frac{b}{4}\left(C_0^2 + \frac{(T_1-T_2)^2}{(a+bC_0)^2}\right)$$

CONSTANTS

(INPUTS : T1, T2, α, a, b, C1, C2)

# 0 INPUT	X1 = T1	Y1 = T2	Z1 = α
# 1	X1 = X1 + Y1 (T_1+T_2)	Y1 = X1 − Y1 (T_1-T_2)	Z1 = Z1 · C2 $(\alpha C_2$
# 2	X1 = X1/2 $\left(\frac{T_1+T_2}{2}\right)$	Y1 = Y1 * Y1 $(T_1-T_2)^2$	Z1 = Z1 + C1 $(C_0=(C_1+\alpha C_2$
# 3	X2 = a · Z1 $(a \cdot C_0)$	Y2 = Z1 * Z1 $(C_0)^2$	Z1 = b · Z1 $(b \cdot C_0$
# 4	X2 = X2/2 $(\frac{a}{2}C_0)$	Y2 = b · Y2 (bC_0^2)	Z1 = a + Z1 $(a+bC_0)$
# 5	X1 = X1 − X2 $\left(\frac{T_1+T_2}{2} - \frac{a}{2}C_0\right)$	Y2 = Y2/4 $\left(\frac{b}{4}C_0^2\right)$	Z1 = Z1 * Z1 $(a+bC_0)^2$
# 6	X1 = X1 − Y2 $\left(\frac{T_1+T_2}{2} - \frac{a}{2}C_0 - \frac{b}{4}C_0^2\right)$	Y2 = b/4 $(\frac{b}{4})$	Z1 = Y1/Z1 $(\Delta T^2/(a+bC_0$
# 7	—	—	Z1 = Z1 * Y2 $\frac{b}{4}(\Delta T^2/(a+bC_0$
# 8	X1 = X1 − Z1 (T_0)	—	—



* Drift time range 300ns/16ns ≈ 20 (5 bits)
* Angle Range ± 16°/1° = ±16 (6 bits)
  (this corresponds to $\delta\alpha = .01$)

Time Budget (T_0)

Drift Time	$\leq$ 300 ns
Angle (2 steps)	100 ns
12 T_0's (8 steps)	400 ns
Final T_0	200 ns
	1000 ns

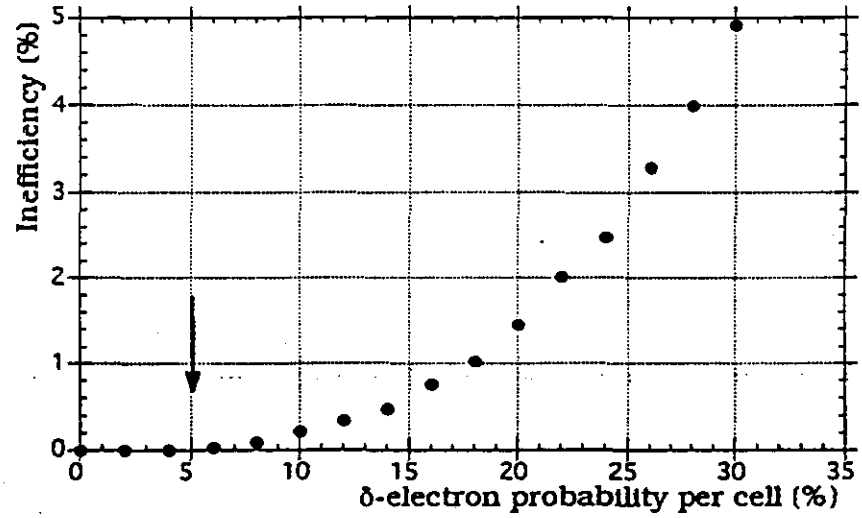
Time Budget (p_T)

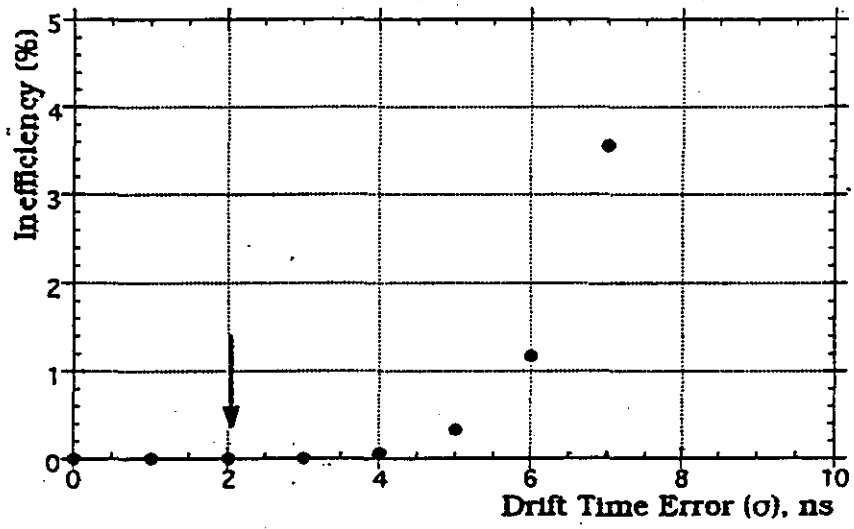
Drift Time	$\leq$ 300 ns
p_T (3 steps)	150 ns
	450 ns

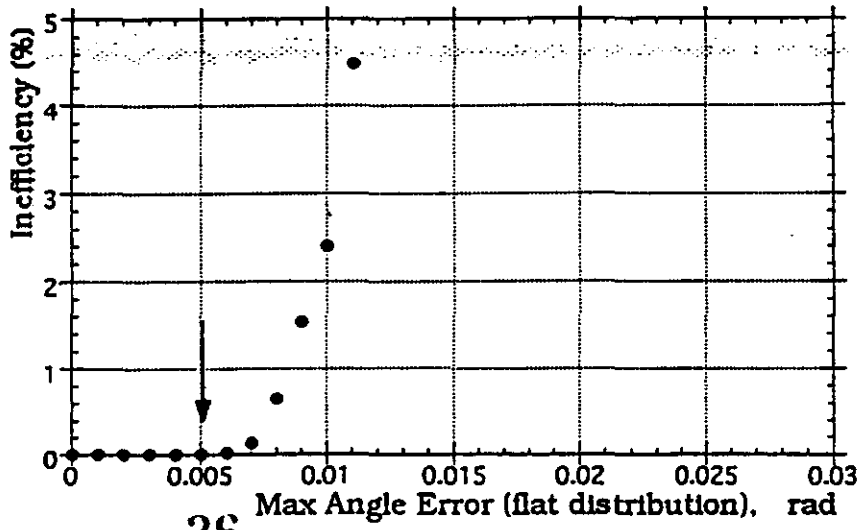
a= 9.9999998E-03 b= 5.327762
KEY=1
eps=.000 Terror(ns)=0.0 Aerror(rad)=.000

P= 20. GeV: Nyes-Nno-Nwrong= 10000 0 0

0	0	0	0	0	0	0
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4	0	0	0	0	0	0
5	0	0	0	0	0	0
6	0	0	0	0	0	0
7	0	0	0	0	0	0
8	0	19	0	0	0	0
9	0	31	0	0	0	0
10	0	194	0	0	0	0
11	0	214	0	0	0	0
12	0	9542	0	0	0	0


Inefficiency (%)
0
1
2
3
4
5
0
5
10
15
20
25
30
35
δ-electron probability per cell (%)


Inefficiency (%)
0
1
2
3
4
5
0
2
4
6
8
10
Drift Time Error (σ), ns


Inefficiency (%)
0
1
2
3
4
5
0
0.005
0.01
0.015
0.02
0.025
0.03
Max Angle Error (flat distribution), rad

Digital Discriminator for GEM LAr Calorimeter

Eric Prebys, Princeton University
SSCL, Sept. 4 1992

Goals

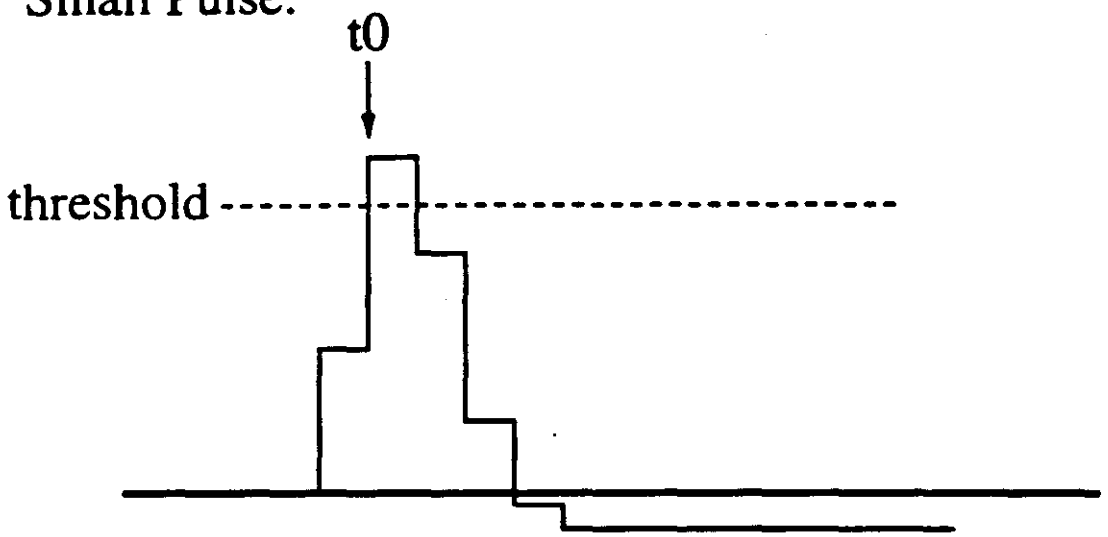
Produce a (simple, cheap) chip that will:

- scan a digitized stream to find pulses
- calculate their energies
- assign them to the <u>correct beam crossings</u>
- discriminate based on the energies
- operate fully pipelined at 60 MHz

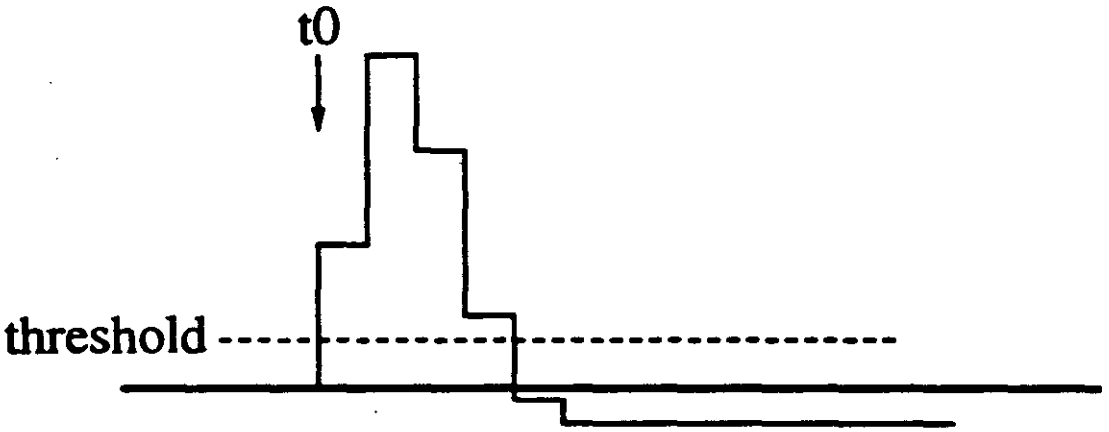
to be used on 5x5 cells in the level 1 trigger.

Time Slewing in Simple Discriminators

Small Pulse:

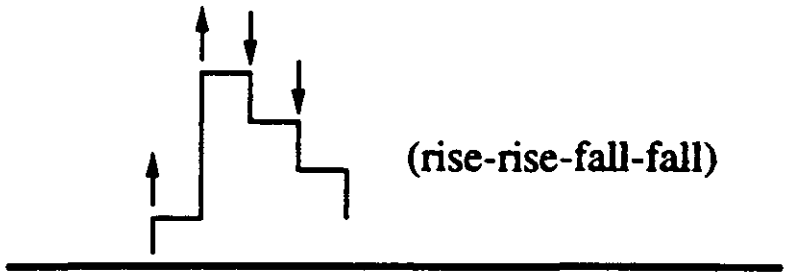


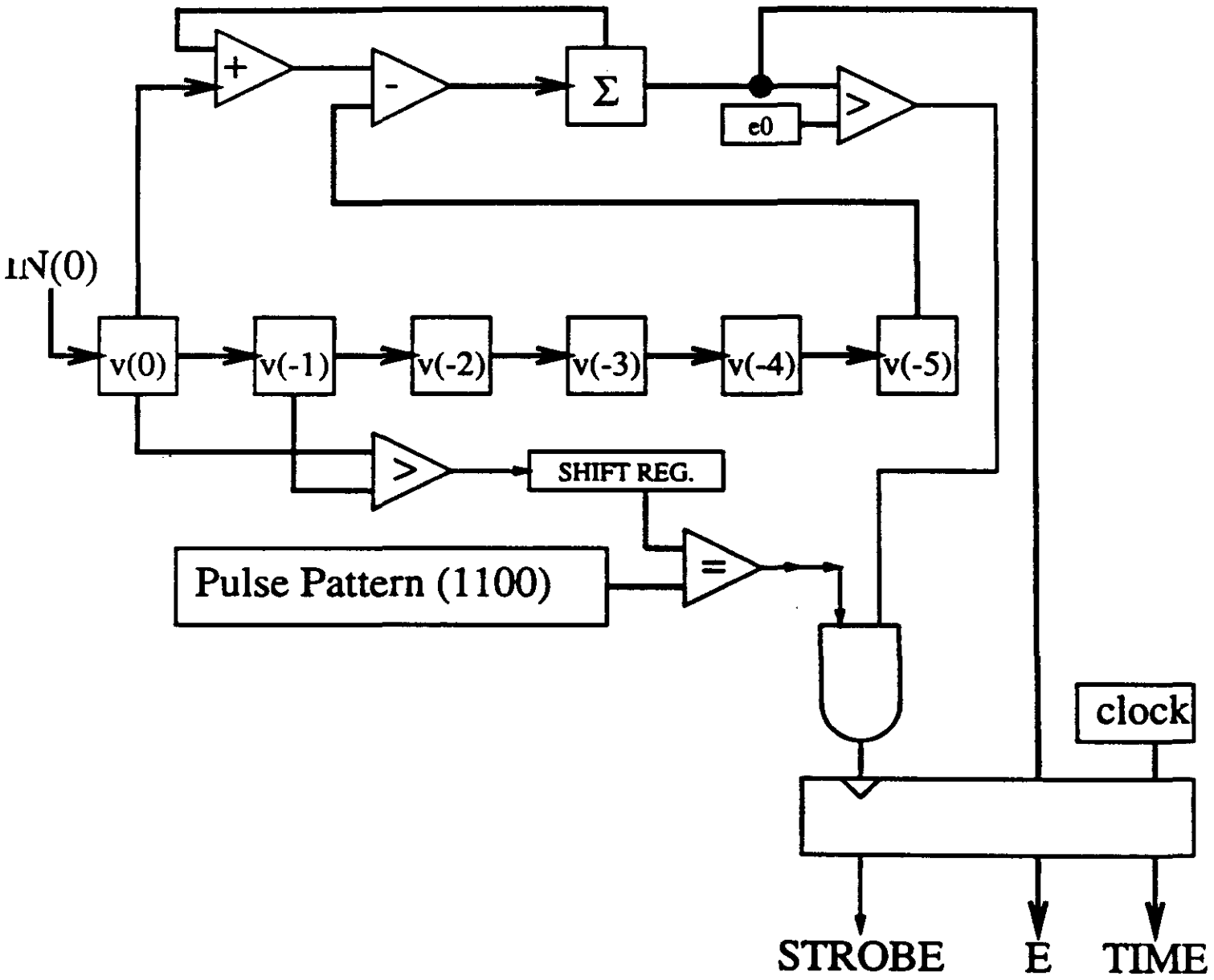
Big Pulse:



Digital Discriminator Scheme

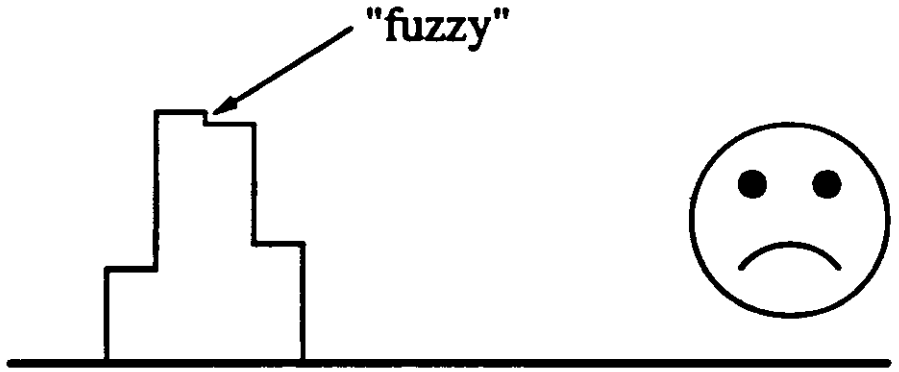
Look for:

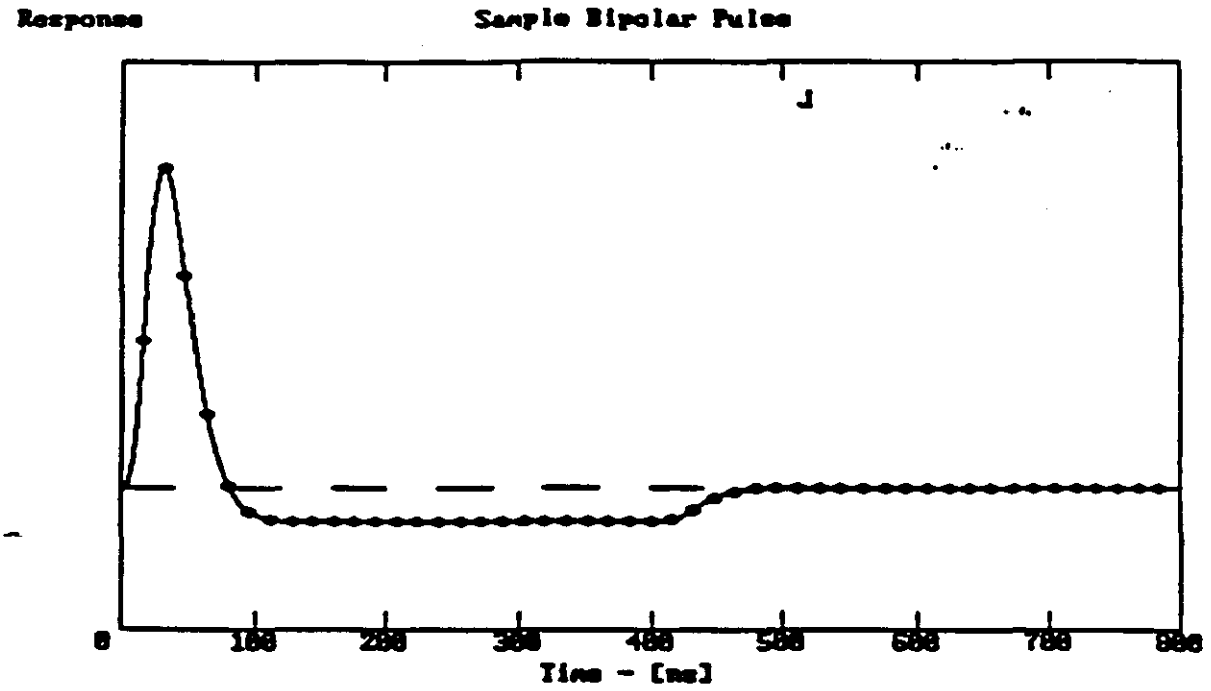




Warning

Pulse Shape Important!





From GEM TN-91-41

Simulation

Signal -

Assume total containment in 5x5

Throw flat distribution 0<E<50 GeV

~~Use~~ Distribute energy over samples based on normal pulse

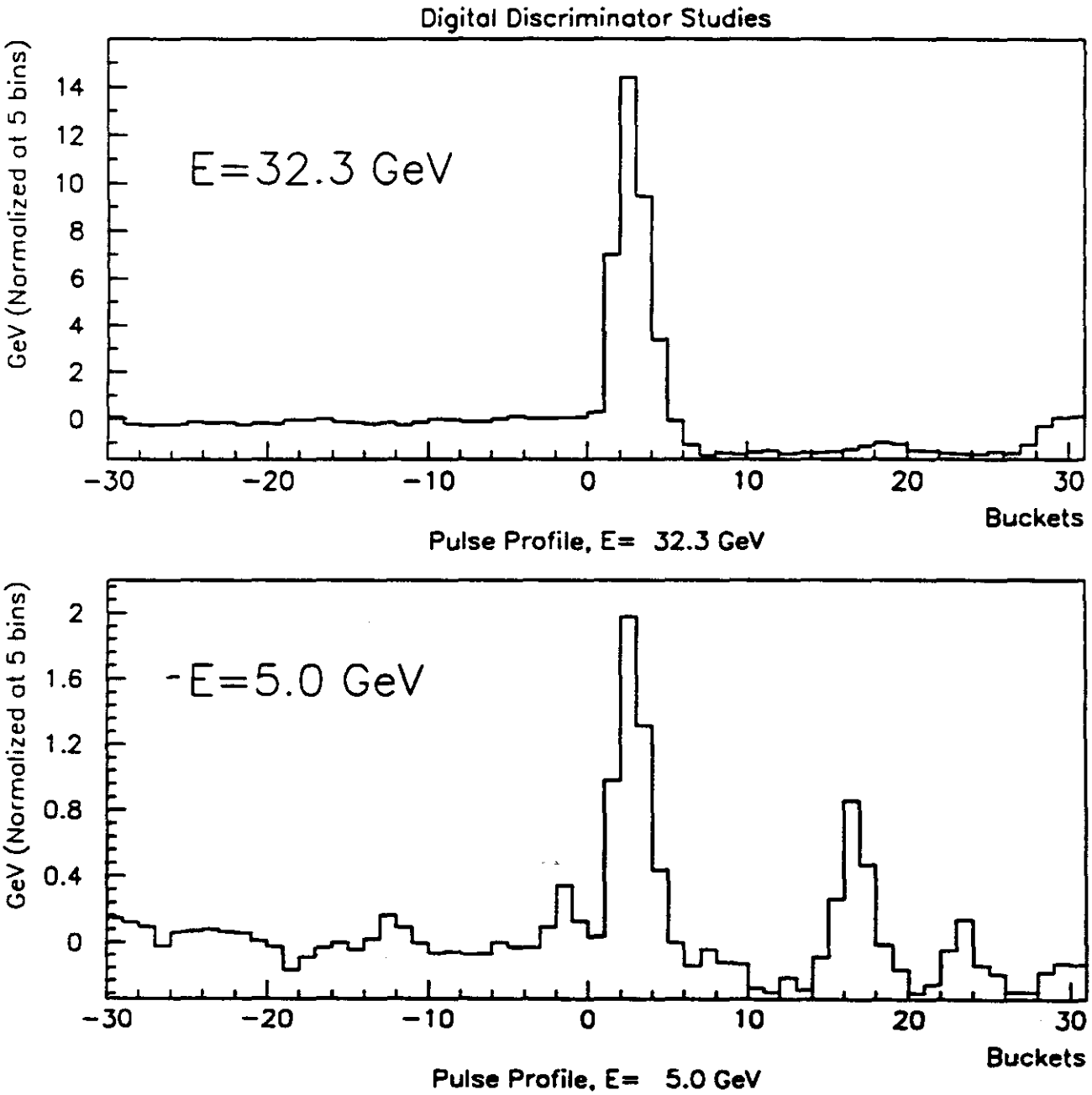
Ignore stochastic fluctuations

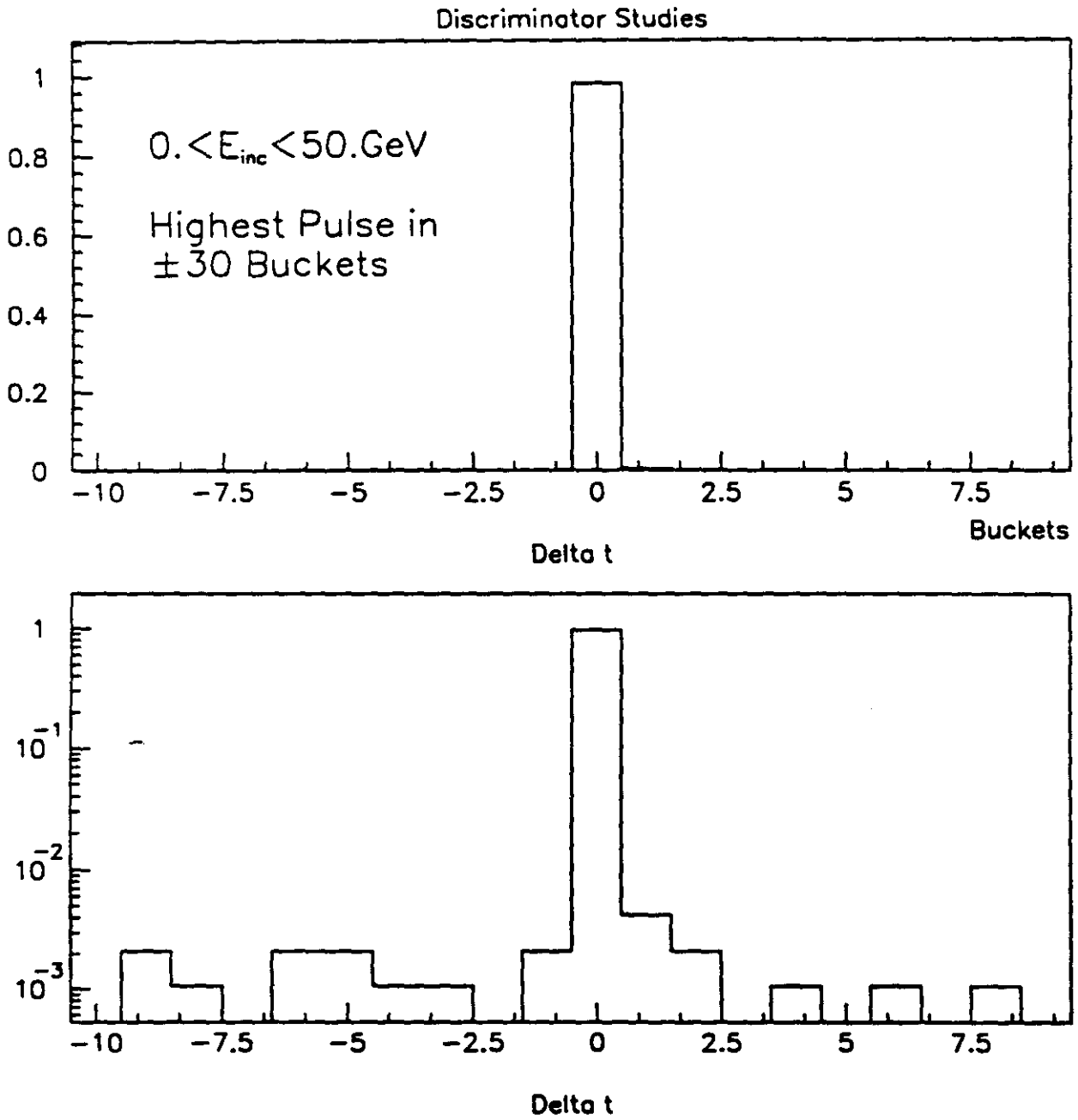
Background -

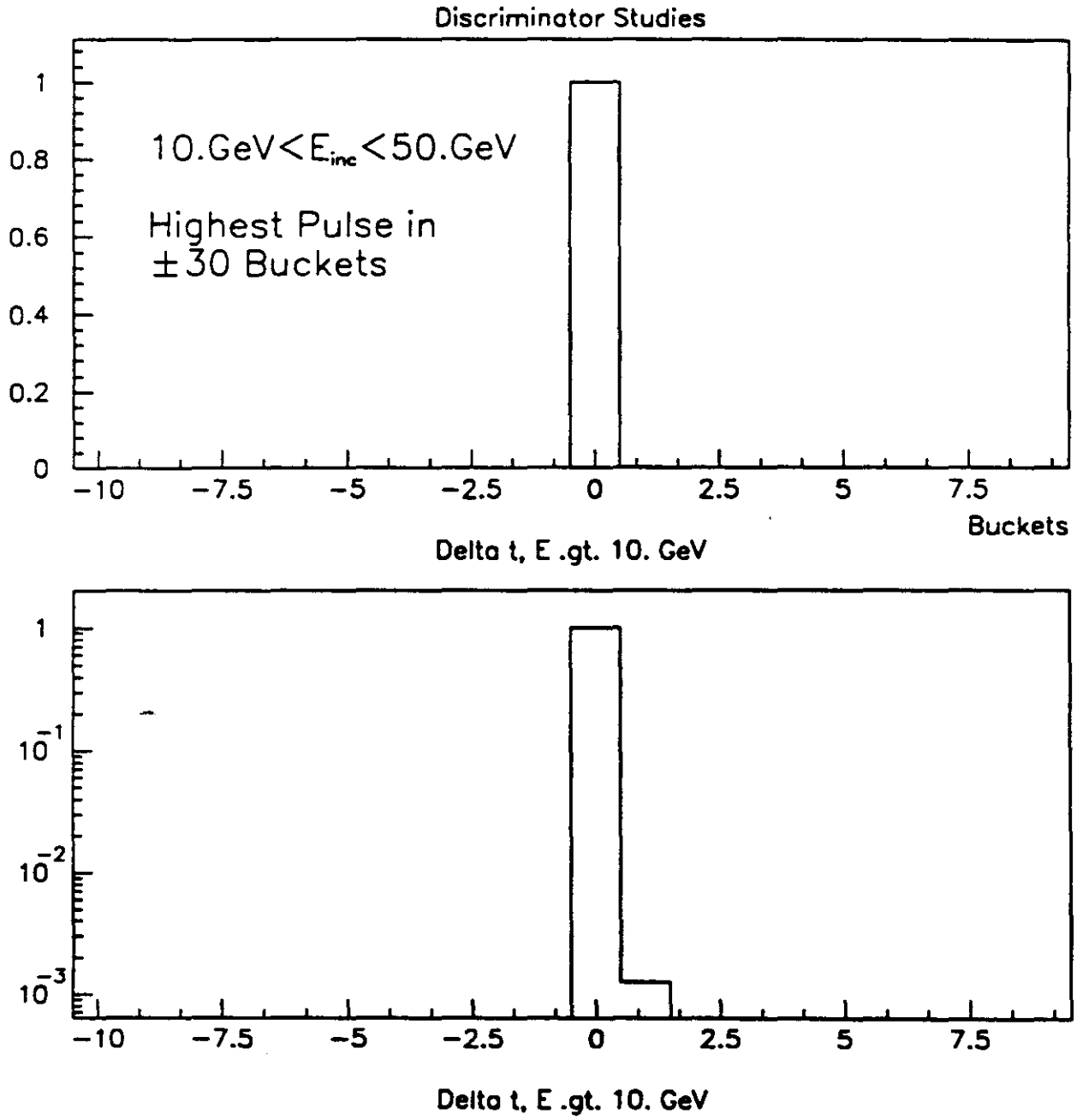
Use randomly placed cells in minimum-bias events to generate a time profile

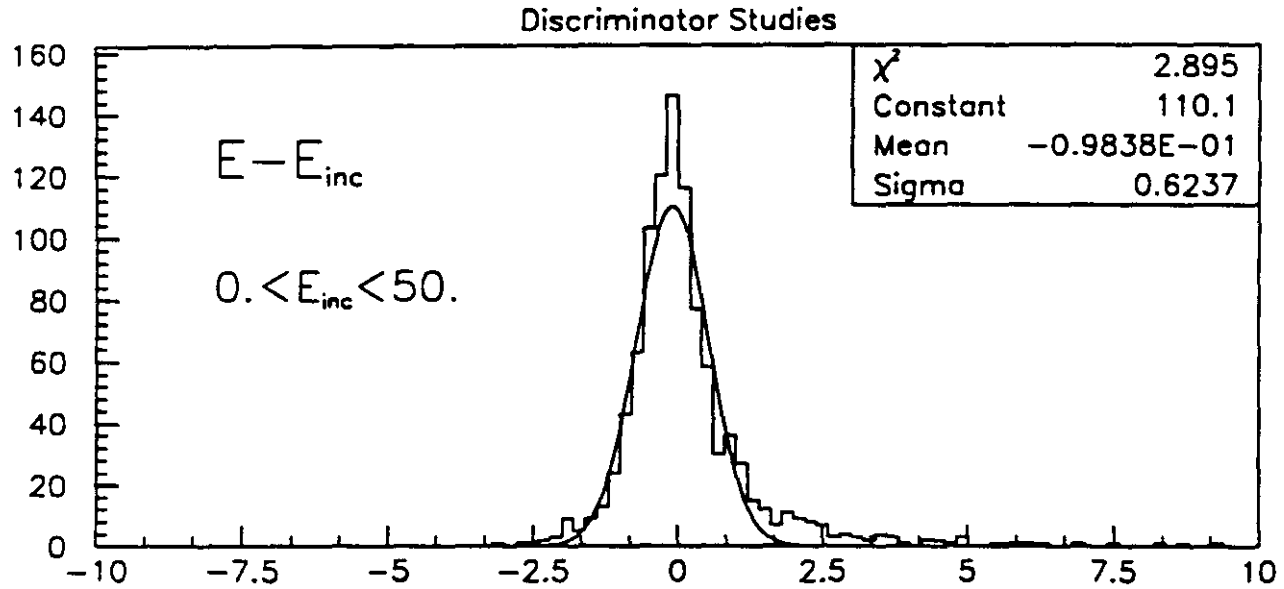
Add in thermal noise (incorrectly, worst case)

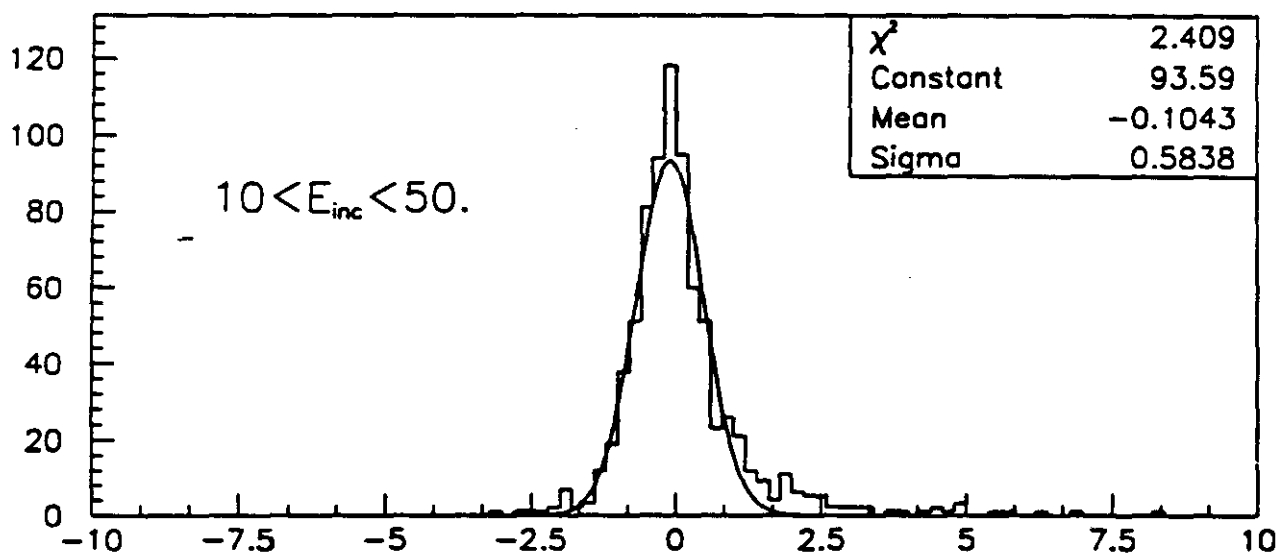
Apply algorithm to window ± 30 buckets from crossing of interest


Digital Discriminator Studies
GeV (Normalized at 5 bins)
E=32.3 GeV
14
12
10
8
6
4
2
0
-30
-20
-10
0
10
20
30
Buckets
Pulse Profile, E= 32.3 GeV
GeV (Normalized at 5 bins)
E=5.0 GeV
2
1.6
1.2
0.8
0.4
0
-30
-20
-10
0
10
20
30
Buckets
Pulse Profile, E= 5.0 GeV

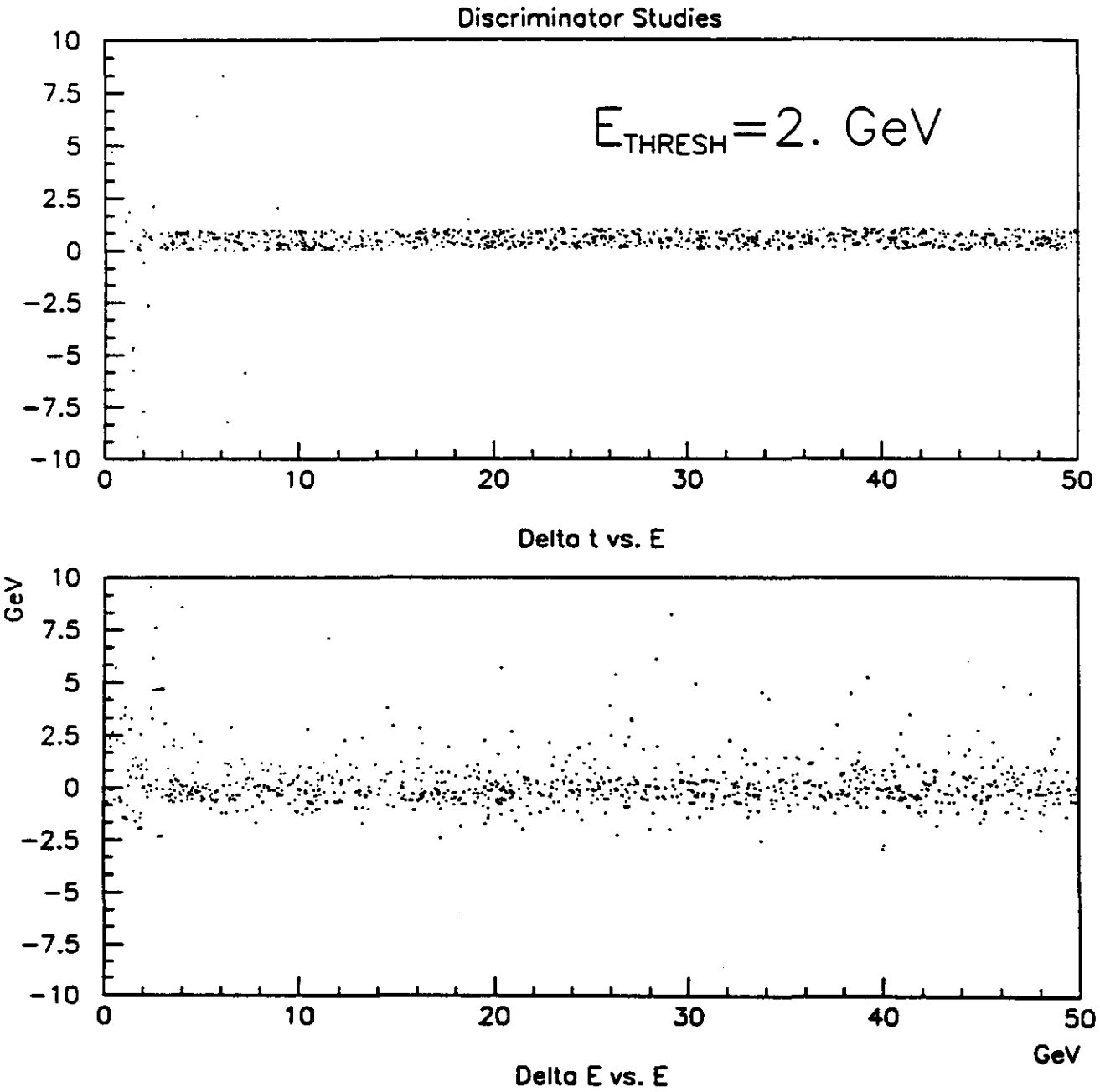

Discriminator Studies
0.<E_inc<50.GeV
Highest Pulse in
±30 Buckets
1
0.8
0.6
0.4
0.2
0
−10
−7.5
−5
−2.5
0
2.5
5
7.5
Buckets
Delta t
1
10^-1
10^-2
10^-3
−10
−7.5
−5
−2.5
0
2.5
5
7.5
Delta t


Discriminator Studies
10.GeV<E_inc<50.GeV
Highest Pulse in
±30 Buckets
1
0.8
0.6
0.4
0.2
0
−10
−7.5
−5
−2.5
0
2.5
5
7.5
Buckets
Delta t, E .gt. 10. GeV
1
10^-1
10^-2
10^-3
−10
−7.5
−5
−2.5
0
2.5
5
7.5
Delta t, E .gt. 10. GeV





Delta E, E .gt. 10. GeV


Discriminator Studies
E_{THRESH}=2. GeV
10
7.5
5
2.5
0
−2.5
−5
−7.5
−10
0
10
20
30
40
50
Delta t vs. E
GeV
10
7.5
5
2.5
0
−2.5
−5
−7.5
−10
0
10
20
30
40
50
GeV
Delta E vs. E

The scheme will clearly work, but can it work at 50 MHz?

No problem with discreet ECL, but...

e.g. off-the-shelf XILINX can do it at ~ 30 Hz

Looking into other options

Plan

- Build and test a prototype, probably start with FPGA

Rad-Hard AMU Development at Oak Ridge National Laboratory

C. L. Britton, Jr.

L. C. Clonts

A. L. Wintenberg

K. F. Read

Presented at the September '92 GEM DAQ Meeting

SSC Laboratory

Dallas, TX

"The submitted manuscript has been authored by a contractor of the U.S. Government under contract No. DE-AC05-84OR21400. Accordingly, the U.S. Government retains a nonexclusive, royalty-free license to publish or reproduce the published form of this contribution, or allow others to do so, for U.S. Government purposes."

*Managed by Martin Marietta Energy Systems, Inc., for the U.S. Department of Energy under contract DE-AC05-84OR21400.

ornl

The Goals...

* Find a CMOS process rad-hard to 3MRad

* Make a memory good to 9 bits in this process

* Make the memory read-time <500ns

* Have power dissipation ~10mW/channel

* Have depth => 128 cells

What we are planning to submit...

* 8x128 memory chip with readout (interdigitated decode,
  4 channels VWVR, 4 channels VWCR,
  4.966mm x 5.934mm)

* 8x128 memory chip with readout (block decode,
  4 channel VWVR, 4 channels VWCR,
  5.208mm x 5.934mm)

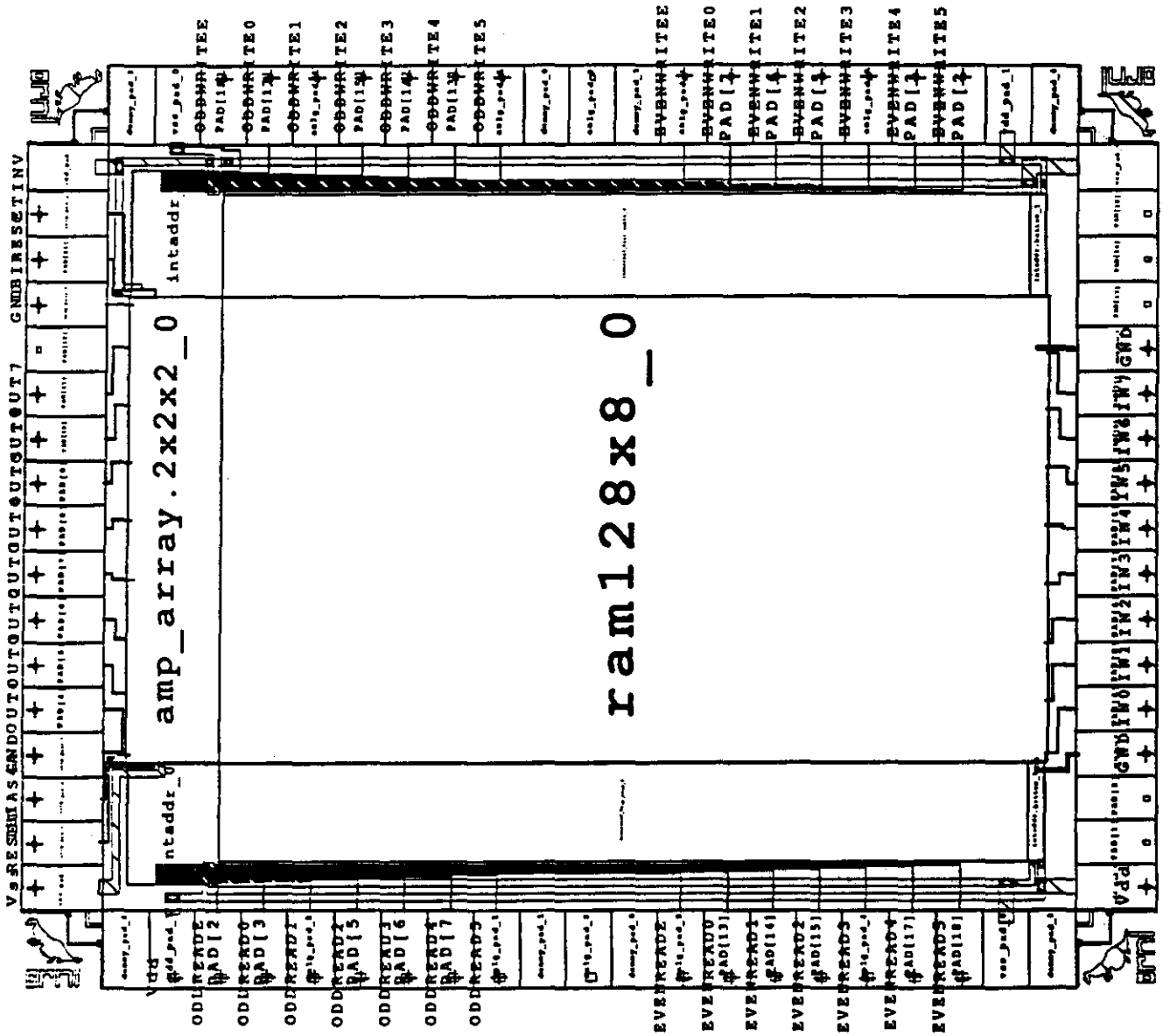
* 4a and 5c opamp chip

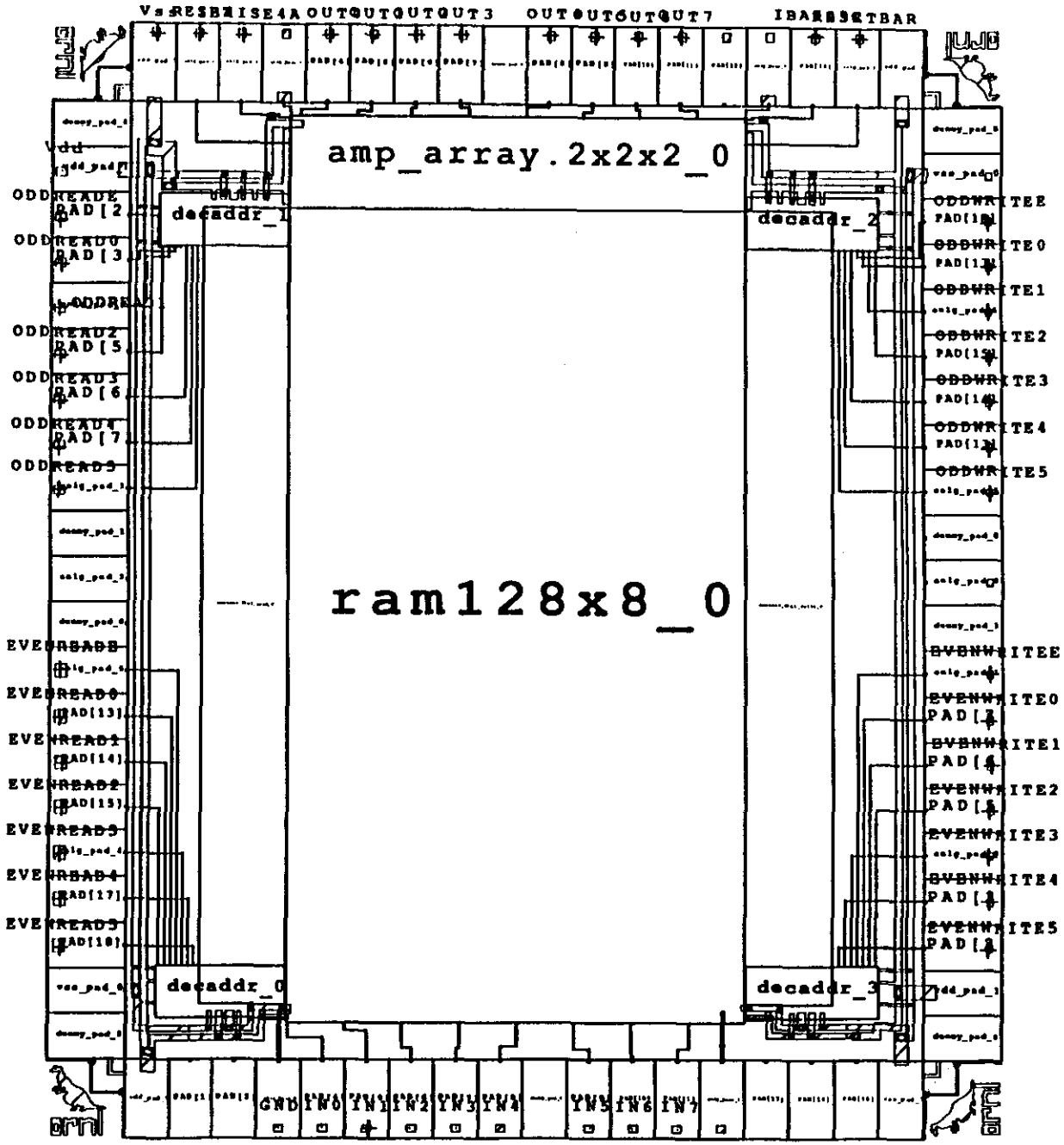
* Decoder pieces chip

OAK RIDGE NATIONAL LABORATORY

Instrumentation and Controls Division

DATE: Sep 2, 1992	Scale: lambda/inch
Filename: interleaf_padframe.mag	User: clonts





OAK RIDGE NATIONAL LABORATORY

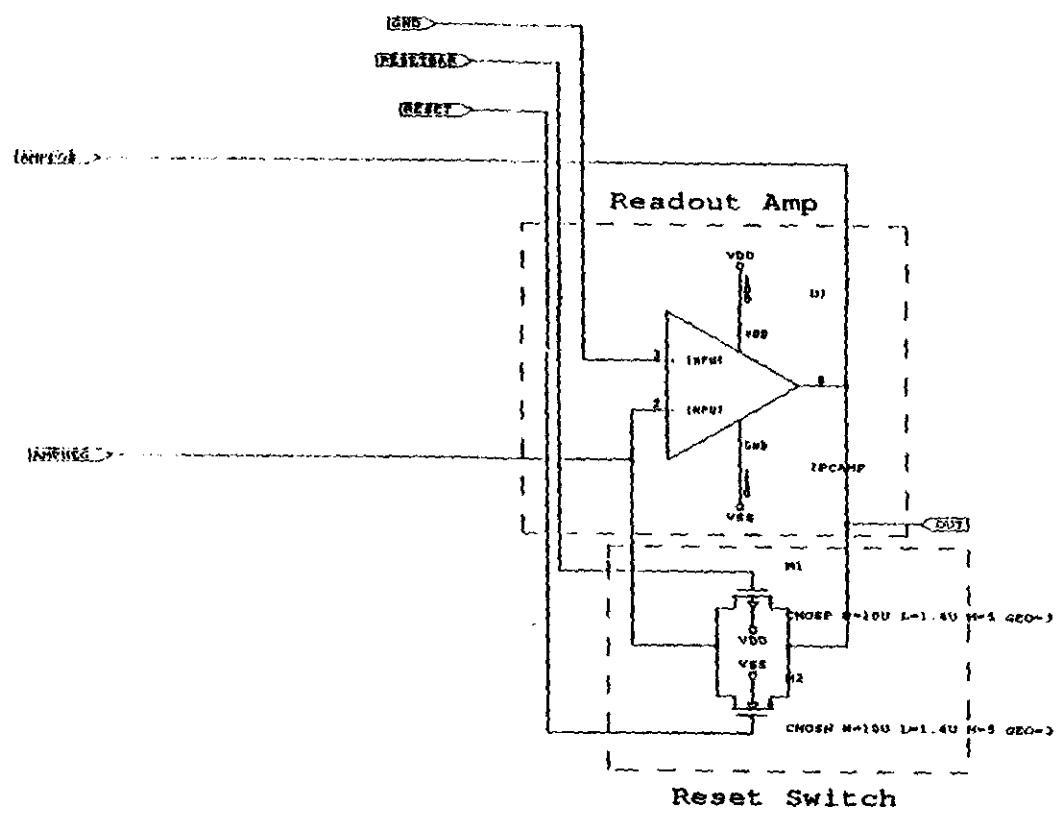
Instrumentation and Controls Division

DATE: Sep 2, 1992

Scale: lambda/inch

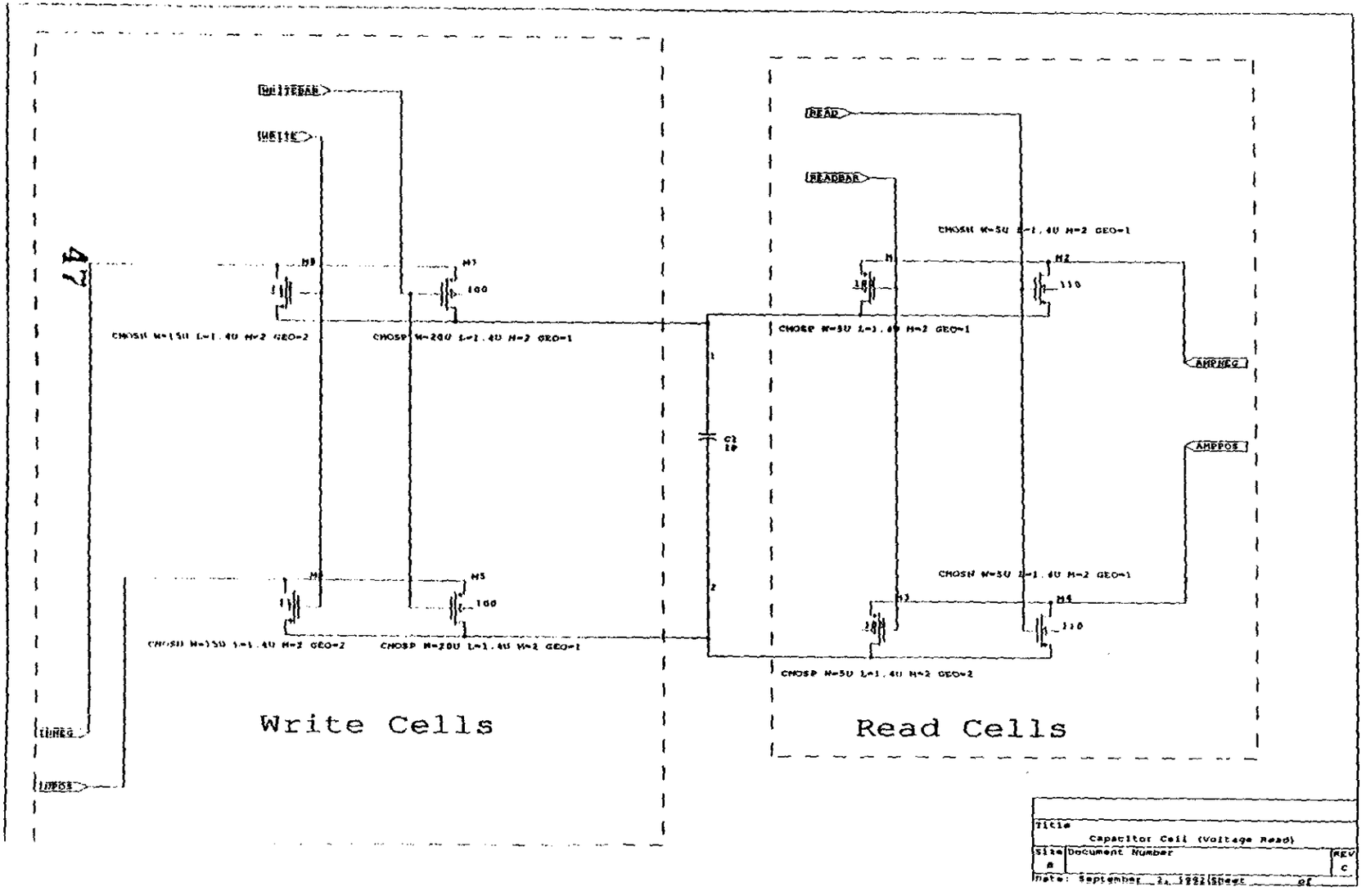
Filename: decoder padframe.mag

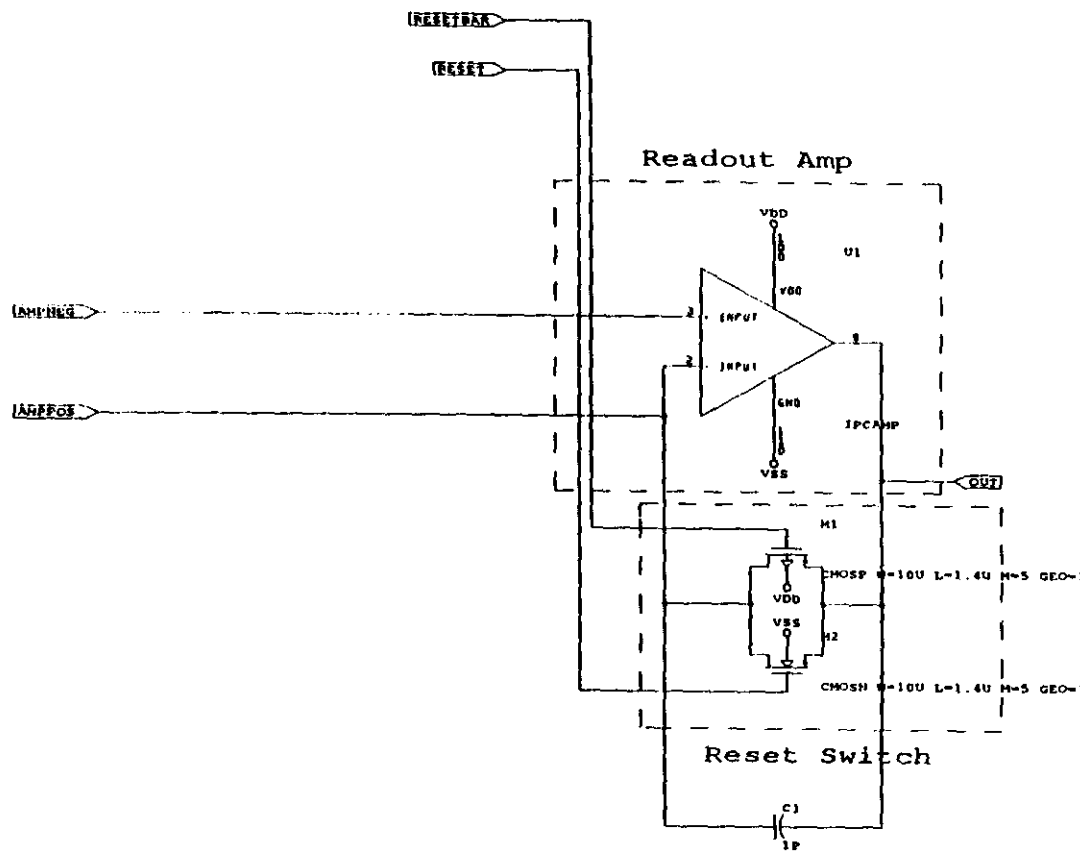
User: clonts



PRELIMINARY SCHEMATIC

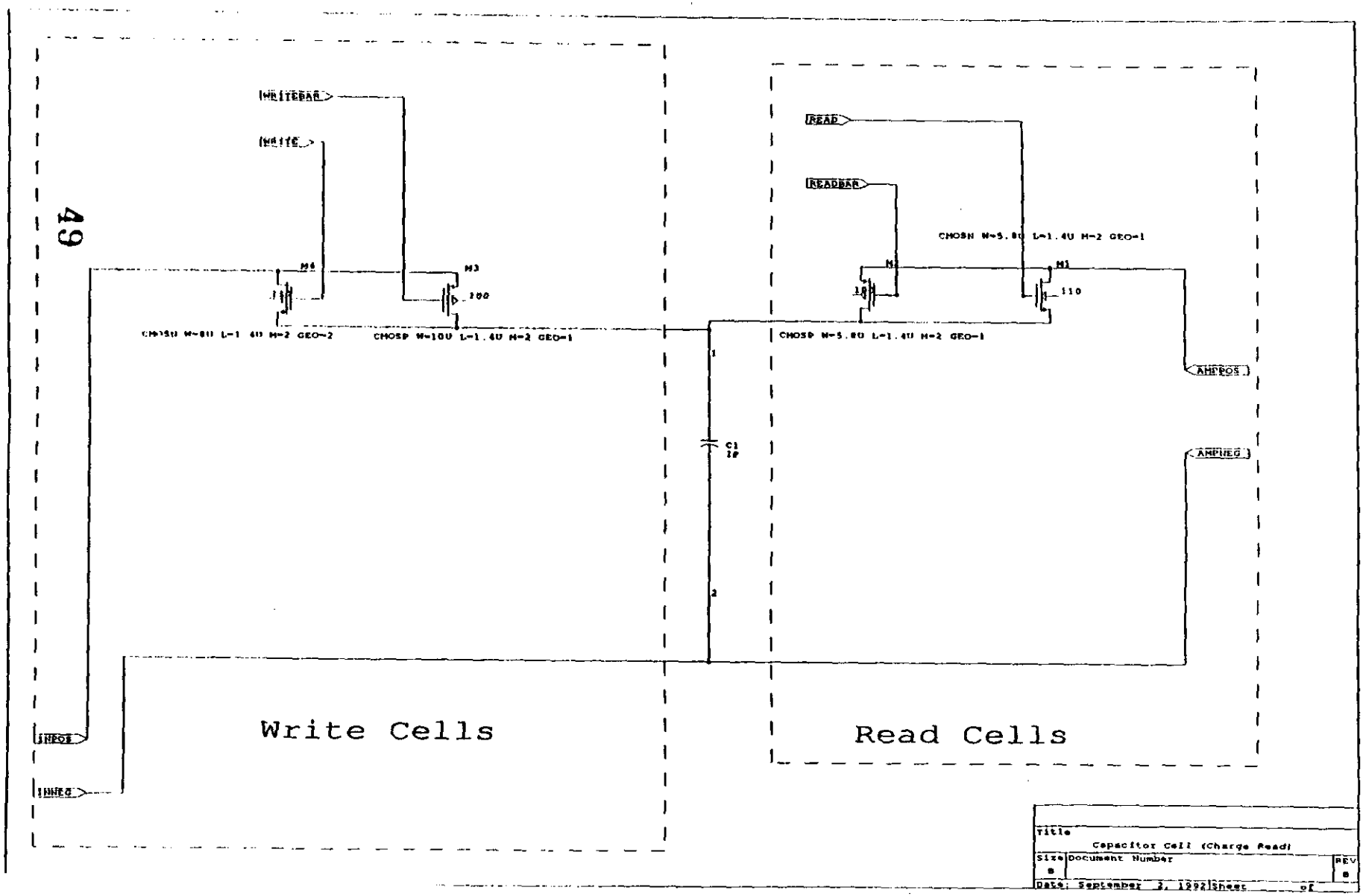
Oak Ridge National Laboratory C. L. Britton, Jr.		
Title Voltage Read Block Diagram		
Size B	Document Number	REV B
Date: September 2, 1992	Sheet 1 of 1	


WRITEBAR
WRITE
READ
READBAR
M1
M2
M3
M4
M5
M6
100
110
CMOSN W=15U L=1.4U M=2 GEO=2
CMOSP W=20U L=1.4U M=2 GEO=1
CMOSN W=5U L=1.4U M=2 GEO=1
CMOSP W=5U L=1.4U M=2 GEO=1
CMOSN W=5U L=1.4U M=2 GEO=1
CMOSP W=5U L=1.4U M=2 GEO=2
AMPNEG
AMPPOS
C1
1P
Write Cells
Read Cells
Title
Capacitor Cell (Voltage Read)
Size
B
Document Number
REV
C
Date: September 2, 1992
Sheet
of



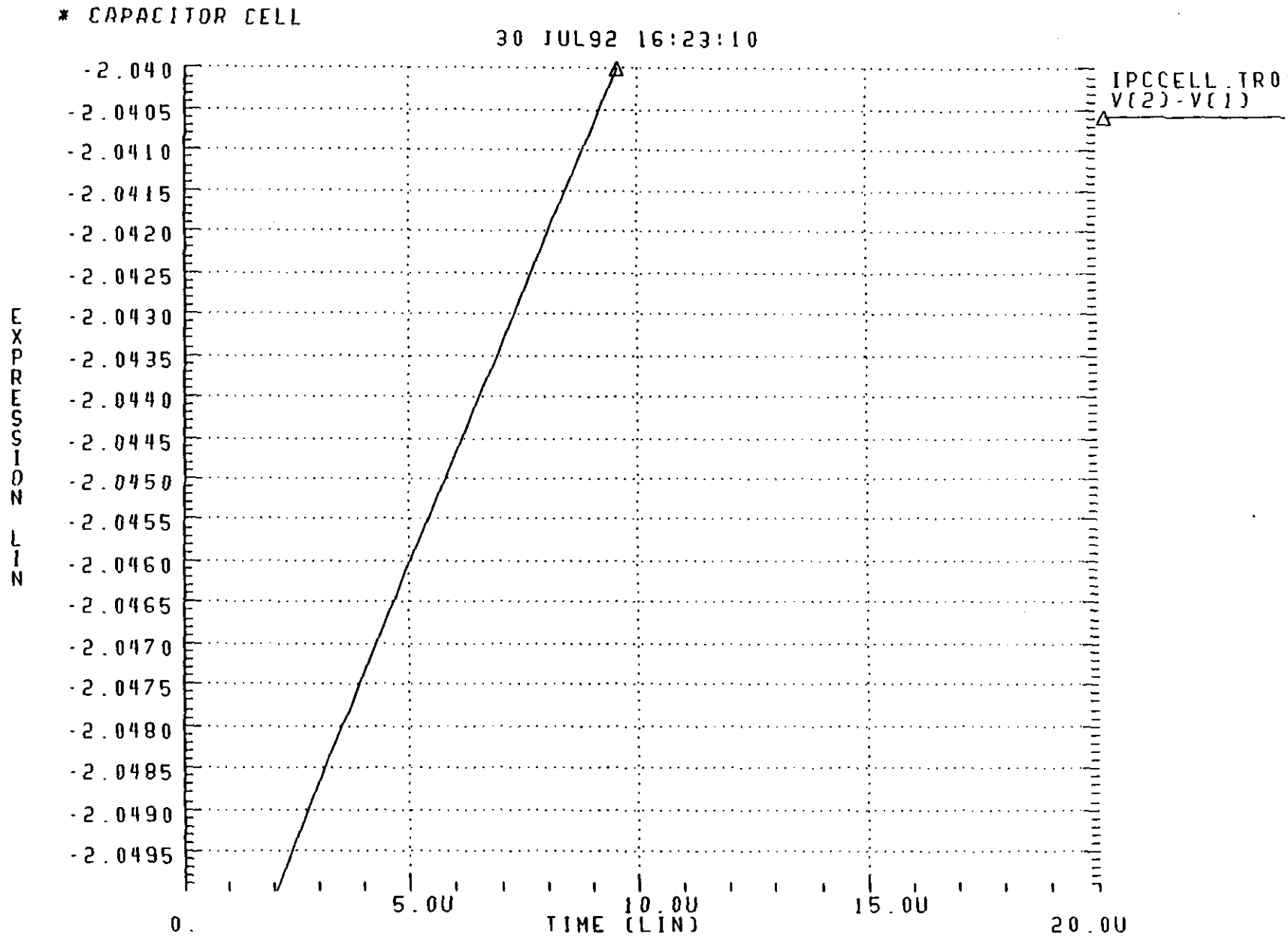
PRELIMINARY SCHEMATIC

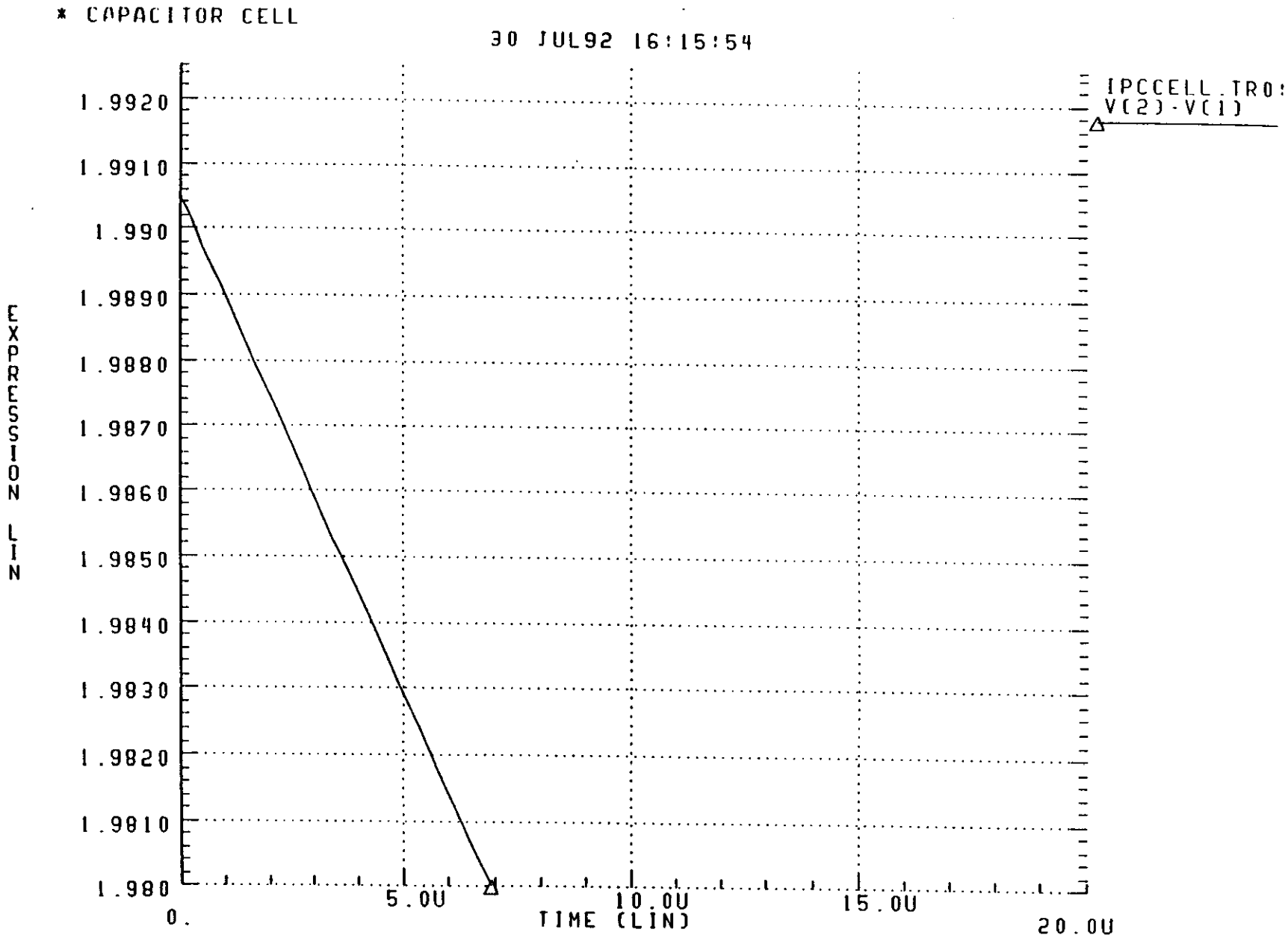
Oak Ridge National Laboratory C. L. Britton, Jr.	
Title Charge Read Block Diagram	
Size B	Document Number
	REV A

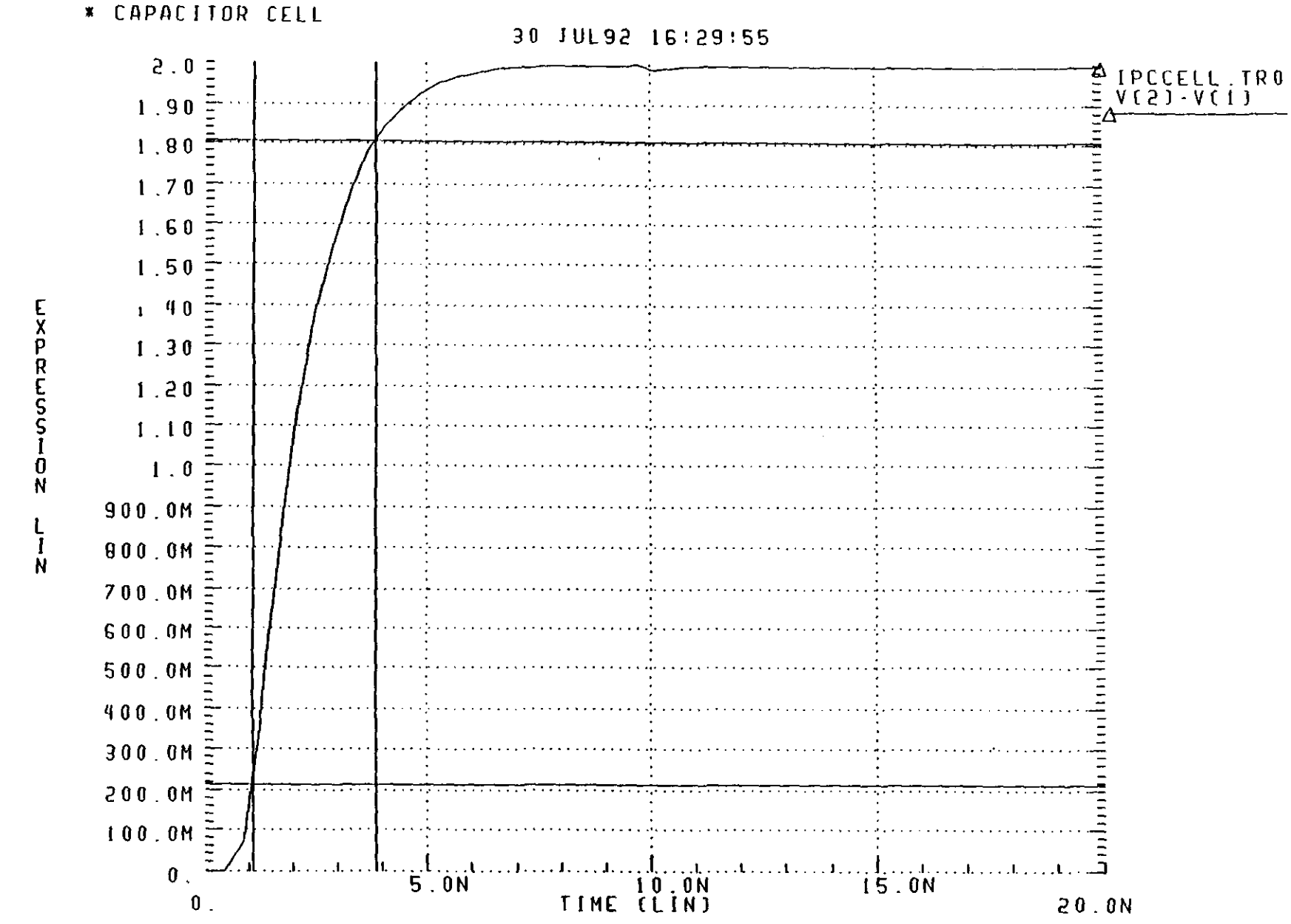

WRITEBAR
WRITE
M4
M3
100
CMOSN W=80U L=1.4U M=2 GEO=2
CMOSP W=100U L=1.4U M=2 GEO=1
1
2
C1
1P
READ
READBAR
M2
M1
110
CMOSN W=5.8U L=1.4U M=2 GEO=1
CMOSP W=5.8U L=1.4U M=2 GEO=1
AMPPOS
AMPNEG
INPOS
INNEG
Write Cells
Read Cells
Title
Capacitor Cell (Charge Read)
Size
B
Document Number
REV
B
Date: September 3, 1992
Sheet
of

The sampling time and rise time determine the precision to 1st order

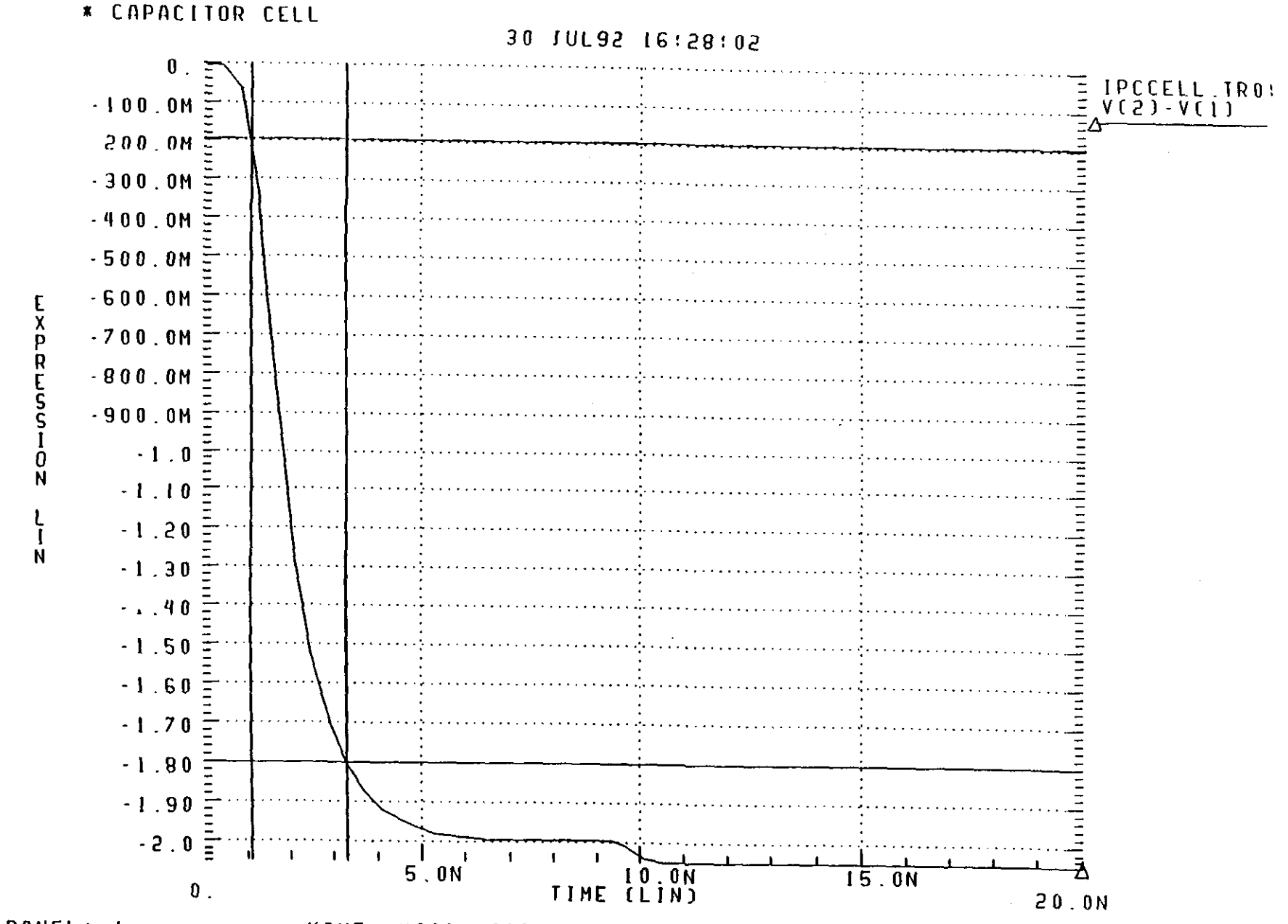
Desired precision (bits)	9	10	11	12
tsamp/trise	2.84	3.15	3.46	3.77


* CAPACITOR CELL
30 JUL92 16:23:10
IPCCELL.TR0:
V(2)-V(1)
EXPRESSION LIN
-2.040
-2.0405
-2.0410
-2.0415
-2.0420
-2.0425
-2.0430
-2.0435
-2.0440
-2.0445
-2.0450
-2.0455
-2.0460
-2.0465
-2.0470
-2.0475
-2.0480
-2.0485
-2.0490
-2.0495
0.
5.0U
10.0U
15.0U
20.0U
TIME (LIN)


* CAPACITOR CELL
30 JUL92 16:15:54
IPCCELL.TR0:
V(2)-V(1)
1.9920
1.9910
1.990
1.9890
1.9880
1.9870
1.9860
1.9850
1.9840
1.9830
1.9820
1.9810
1.980
EXPRESSION LIN
0.
5.0U
10.0U
15.0U
20.0U
TIME (LIN)



PANEL: 1 NAME: V(2)-V(1) X1 = 1.07N Y1 = 211.23M
PANEL: 1 NAME: V(2)-V(1) X2 = 3.85N Y2 = 1.80
DIFFERENCES (CURSOR2 - CURSOR1): DX = 2.78N DY = 1.59



PANEL: 1 NAME: V(2)-V(1) X1 = 1.07N Y1 = -196.24M
PANEL: 1 NAME: V(2)-V(1) X2 = 3.29N Y2 = -1.80
DIFFERENCES (CURSOR2 - CURSOR1): DX = 2.23N DY = -1.61

Parameters that affect read-time

* Frequency response, phase margin, g_m/C_{GS} --> settling time
* Phase margin, g_m/C_{GS} --> reset time
* DC gain --> precision

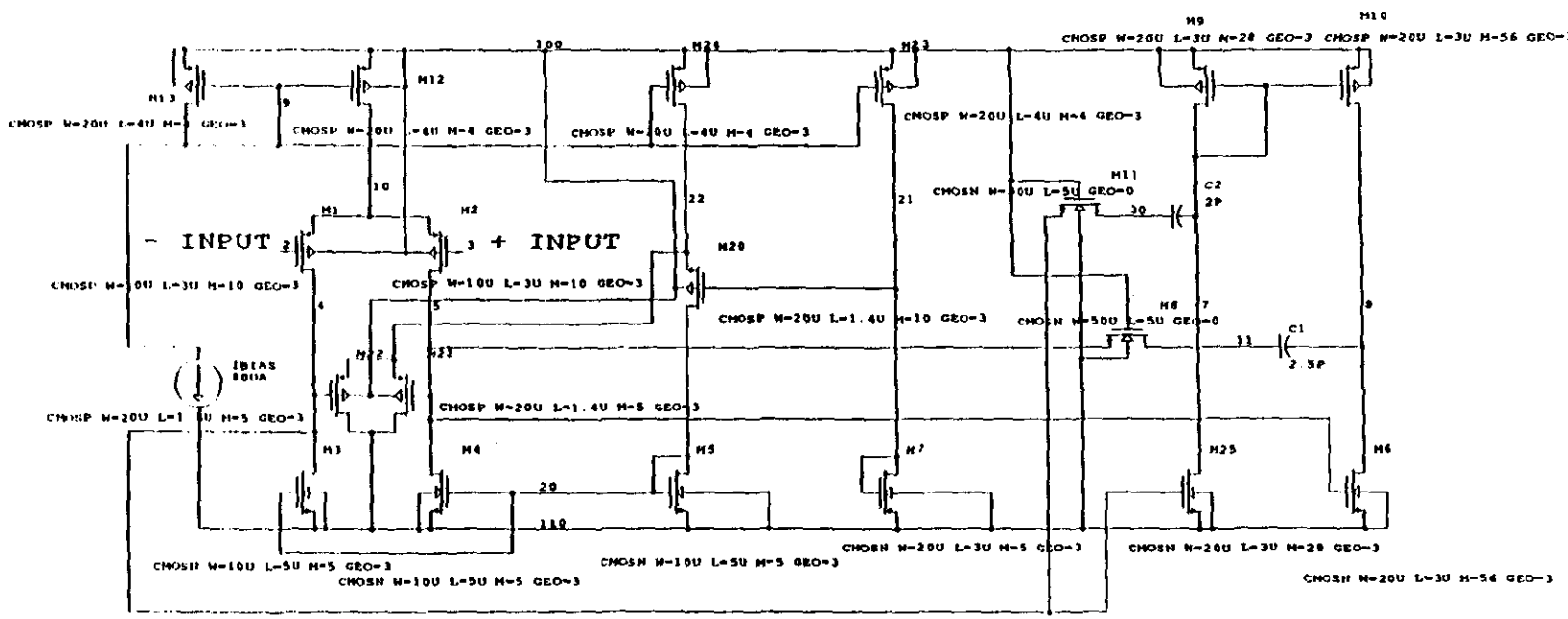
For the topologies chosen..

* Settling time affected by output pole (high bus capacitance)
* Bandwidth determined by input g_m/C_{comp}
* For min. power and area, inputs are PMOS, outputs are NMOS

The opamp characteristics..

Amplifier	IPC4A	IPC5C
Bandwidth	11MHz	11MHz
Phase margin	~60°	~60°
Slew rate	> 20V/μs	>20V/μs
Power	9.4mW	6.7mW

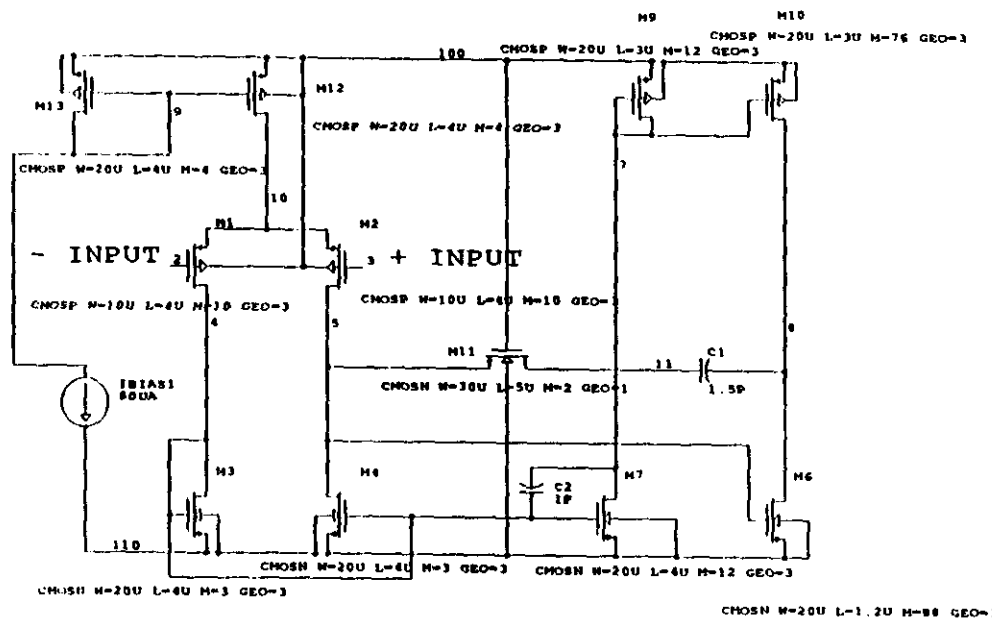
PRELIMINARY SCHEMATIC



PRELIMINARY SCHEMATIC

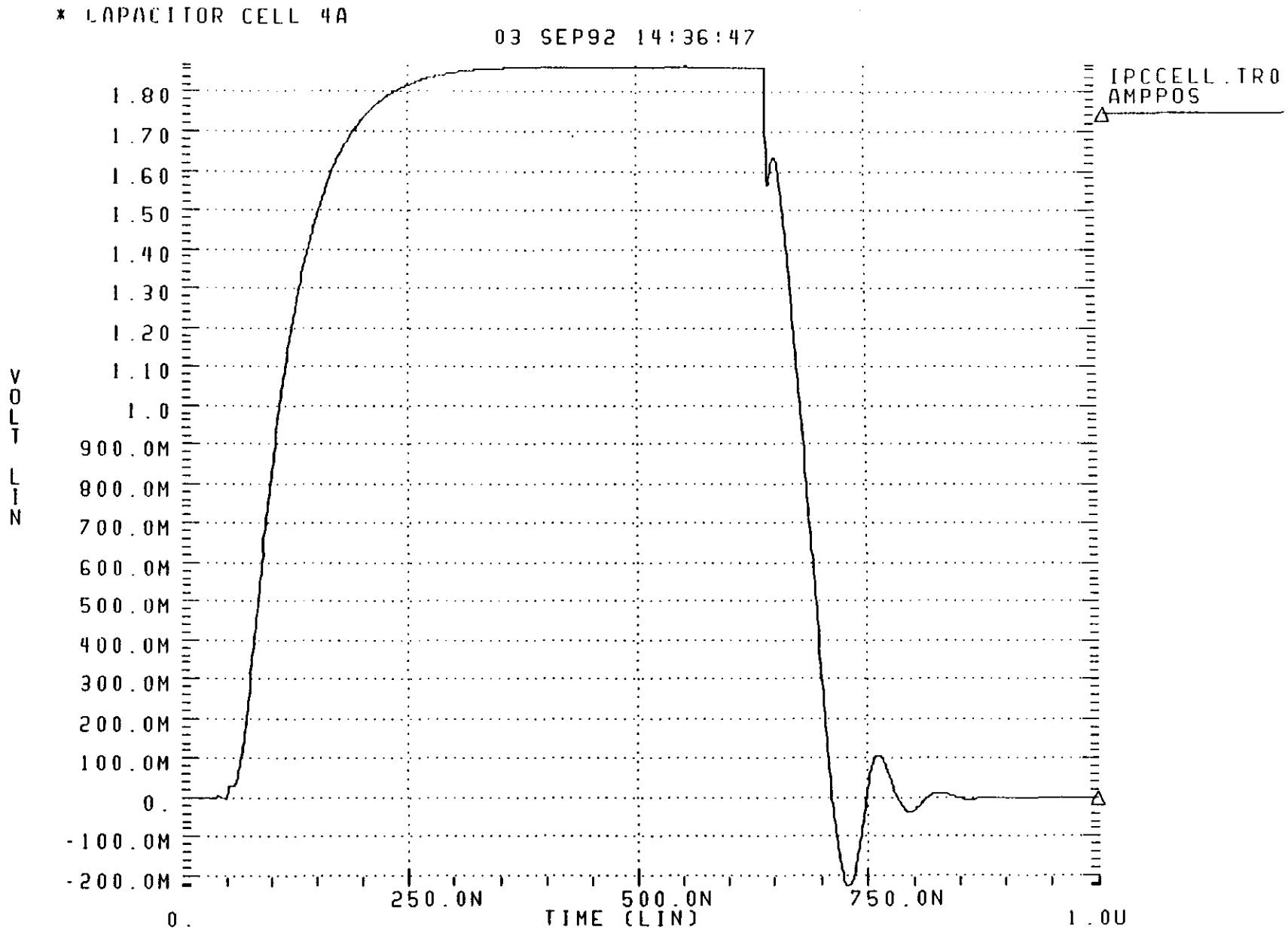
Oak Ridge National Laboratory C. L. Britton, Jr.	
Title	IPC4A
Size B	Document Number
REV H	
Date: July 24, 1992	Sheet 1 of 1

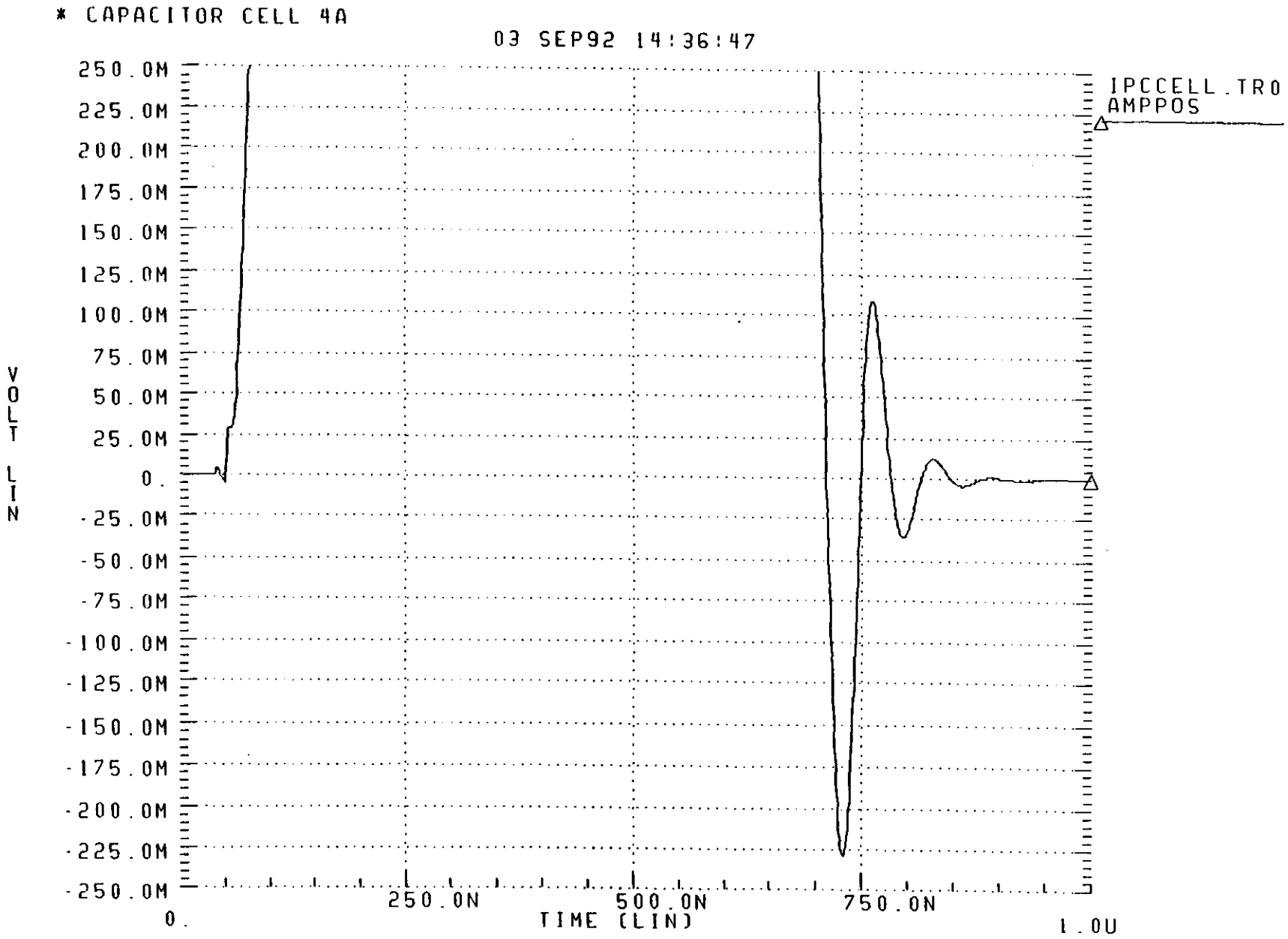
PRELIMINARY SCHEMATIC



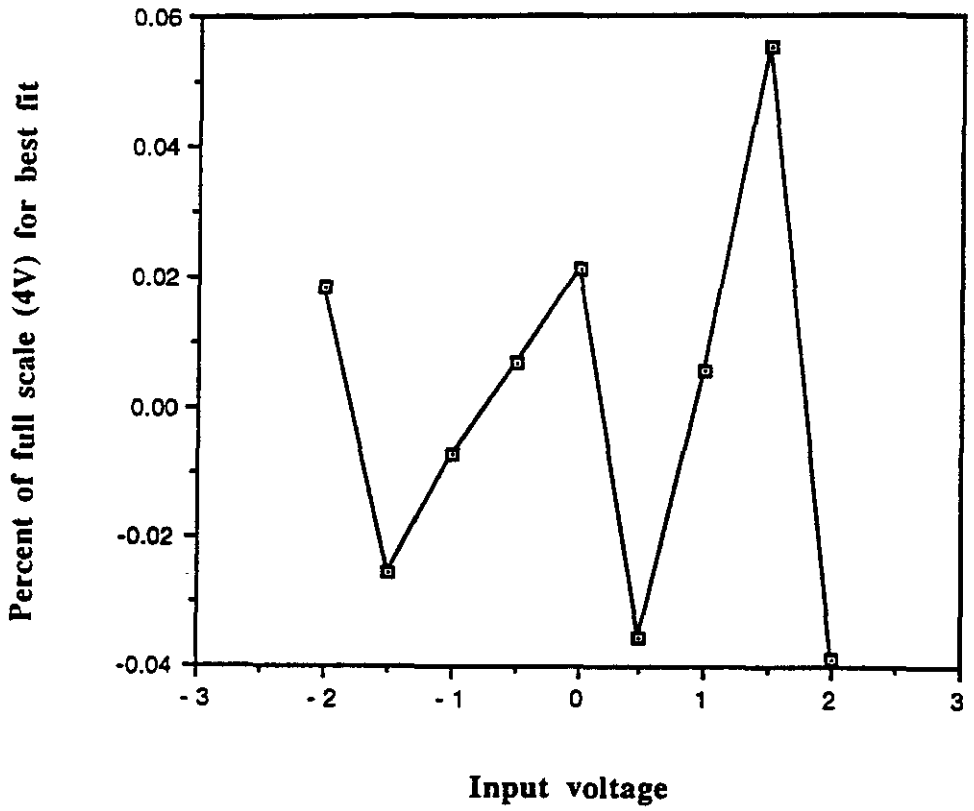
PRELIMINARY SCHEMATIC

Oak Ridge National Laboratory C. L. Britton, Jr.	
Title IPCSC	
Size B	Document Number
REV E	

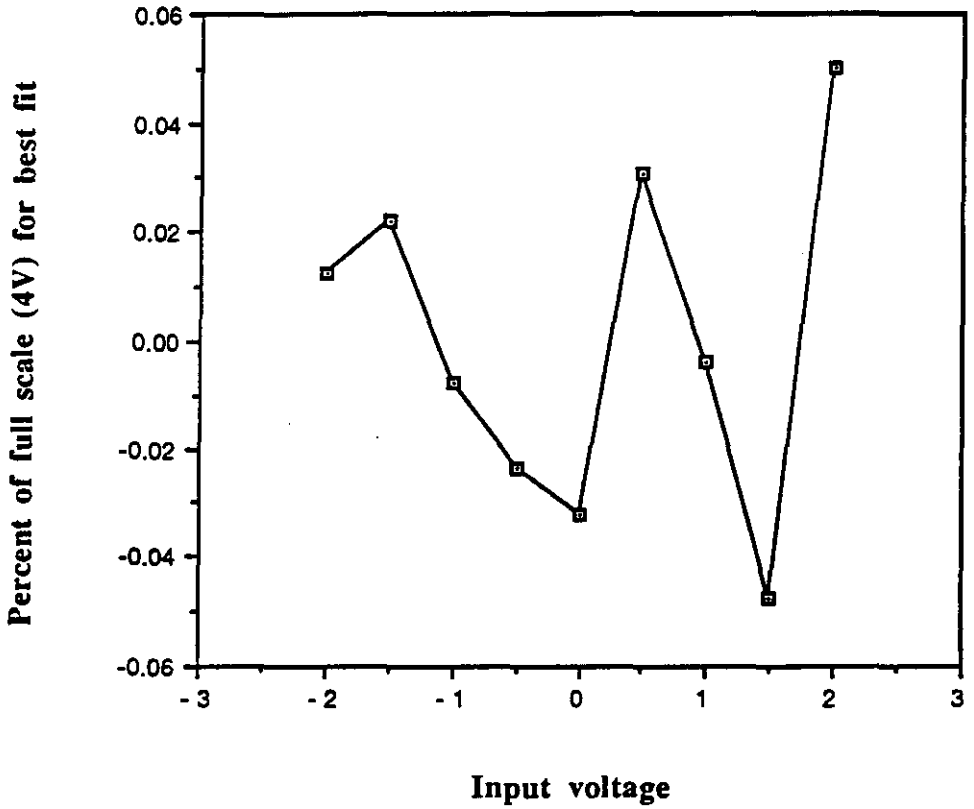

* CAPACITOR CELL 4A
03 SEP92 14:36:47
IPCCELL.TR0
AMPPOS
VOLT LIN
1.80
1.70
1.60
1.50
1.40
1.30
1.20
1.10
1.0
900.0M
800.0M
700.0M
600.0M
500.0M
400.0M
300.0M
200.0M
100.0M
0.
-100.0M
-200.0M
0.
250.0N
500.0N
750.0N
1.0U
TIME (LIN)


* CAPACITOR CELL 4A
03 SEP92 14:36:47
IPCCELL.TR0
AMPPOS
250.0M
225.0M
200.0M
175.0M
150.0M
125.0M
100.0M
75.0M
50.0M
25.0M
0.
-25.0M
-50.0M
-75.0M
-100.0M
-125.0M
-150.0M
-175.0M
-200.0M
-225.0M
-250.0M
VOLT LIN
0.
250.0N
500.0N
750.0N
1.0U
TIME (LIN)

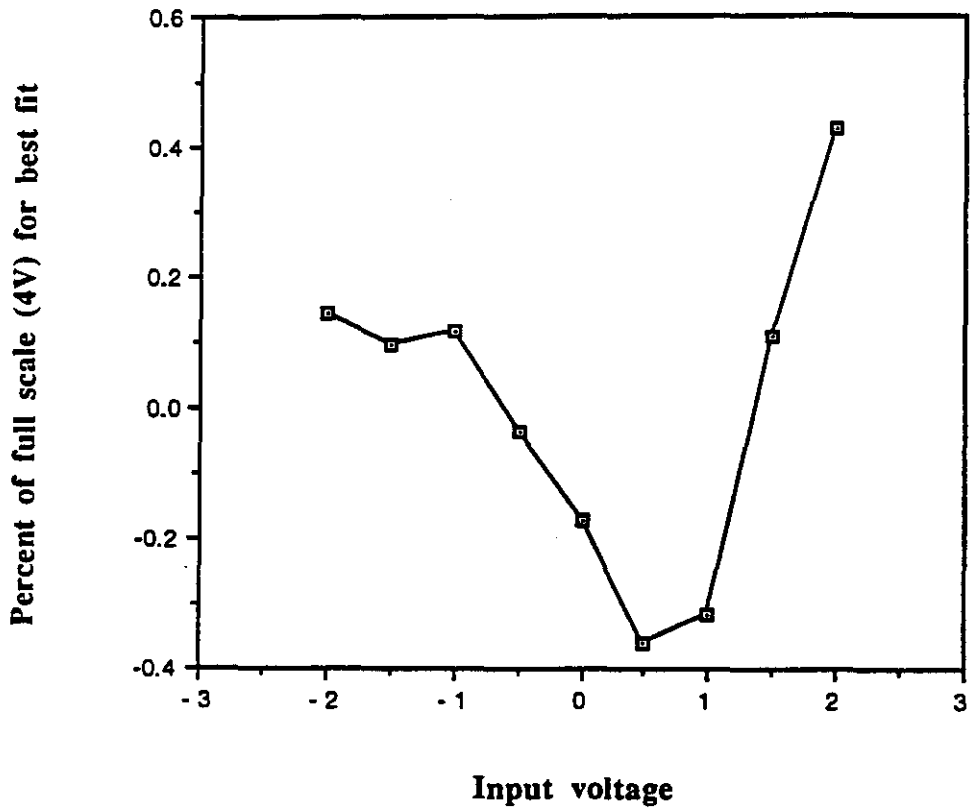
Integral linearity of VWVR, IPC4a, 375ns Tset (10 bit)



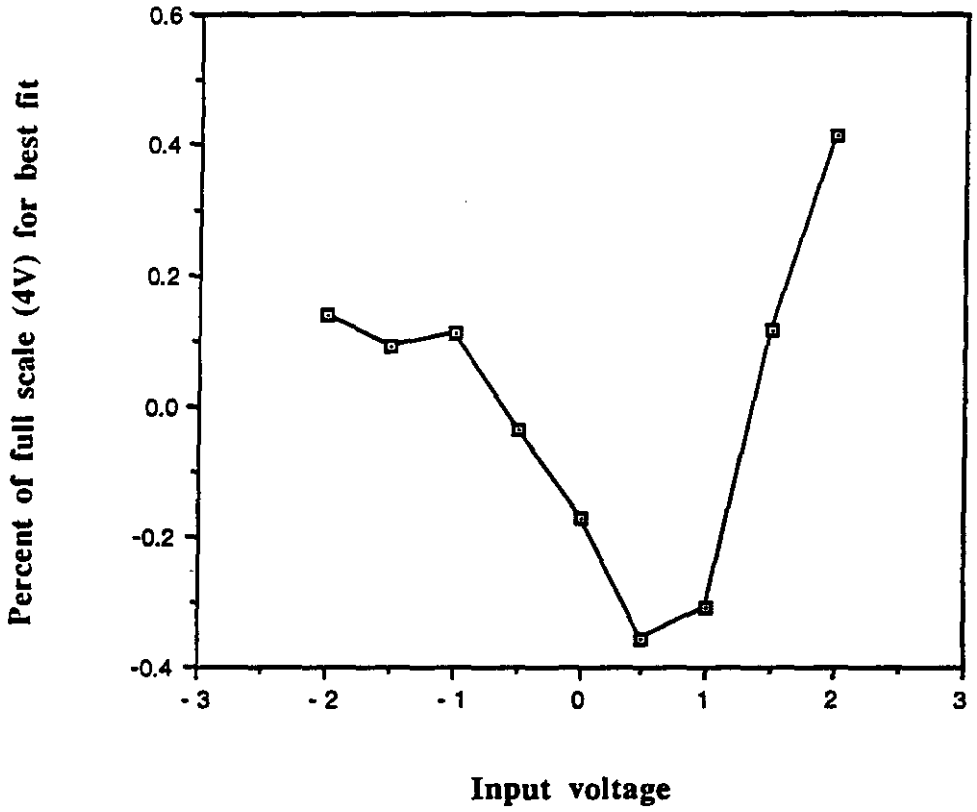
Integral linearity of VWVR, IPC5c, 315ns Tset (10 bit)

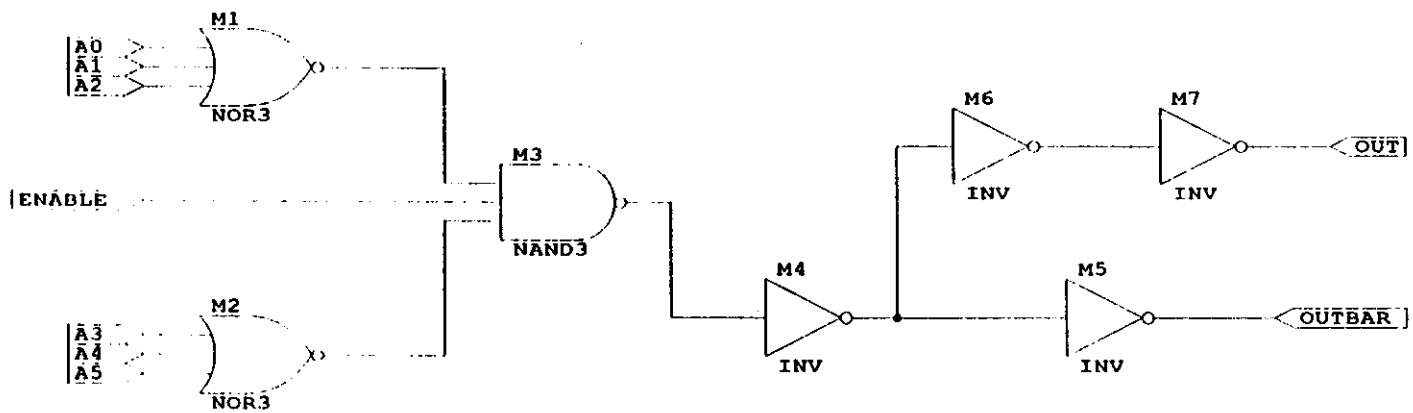


Integral linearity of VWCR, IPC4a, 495ns Tset (10 bit)

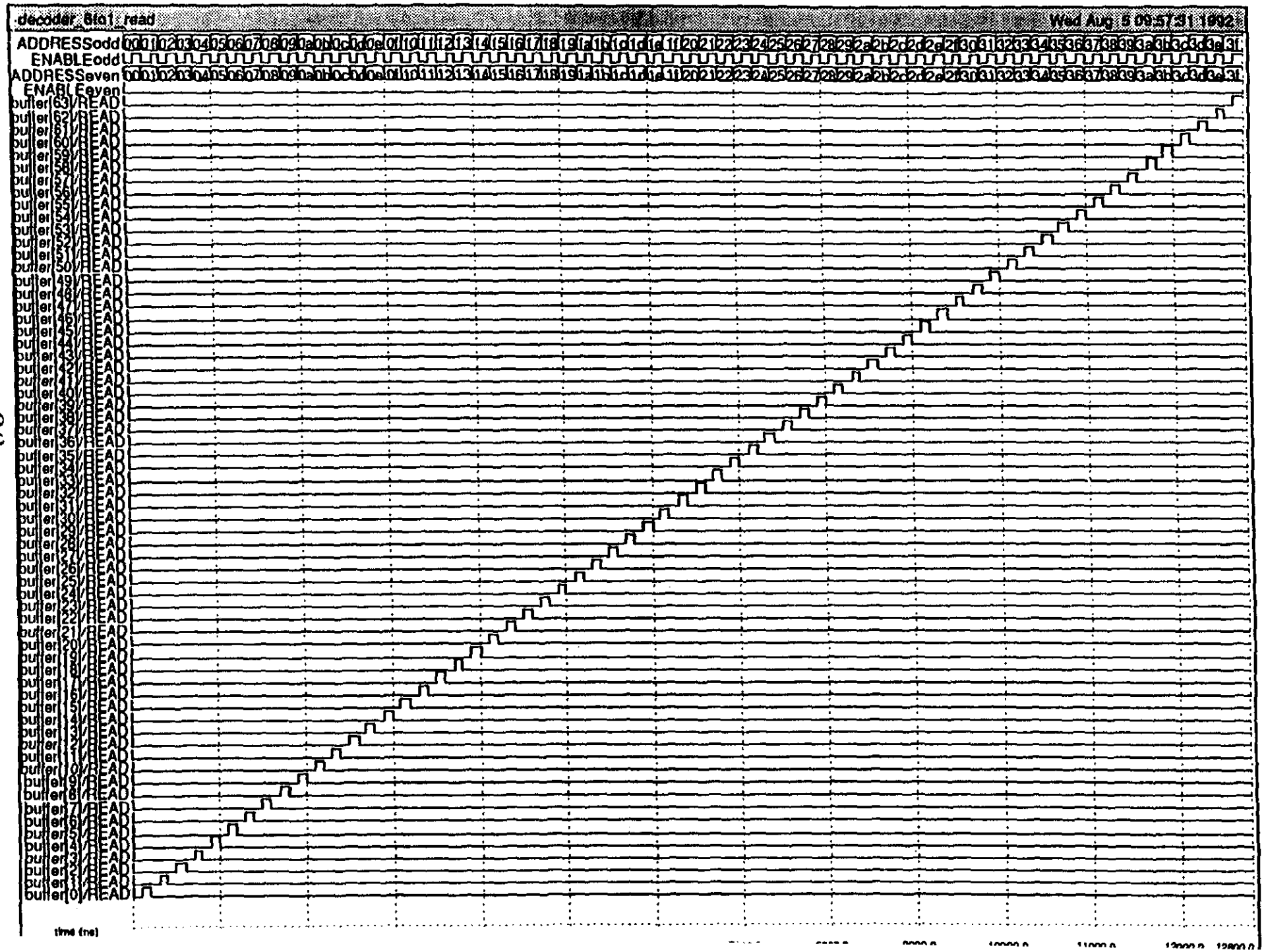


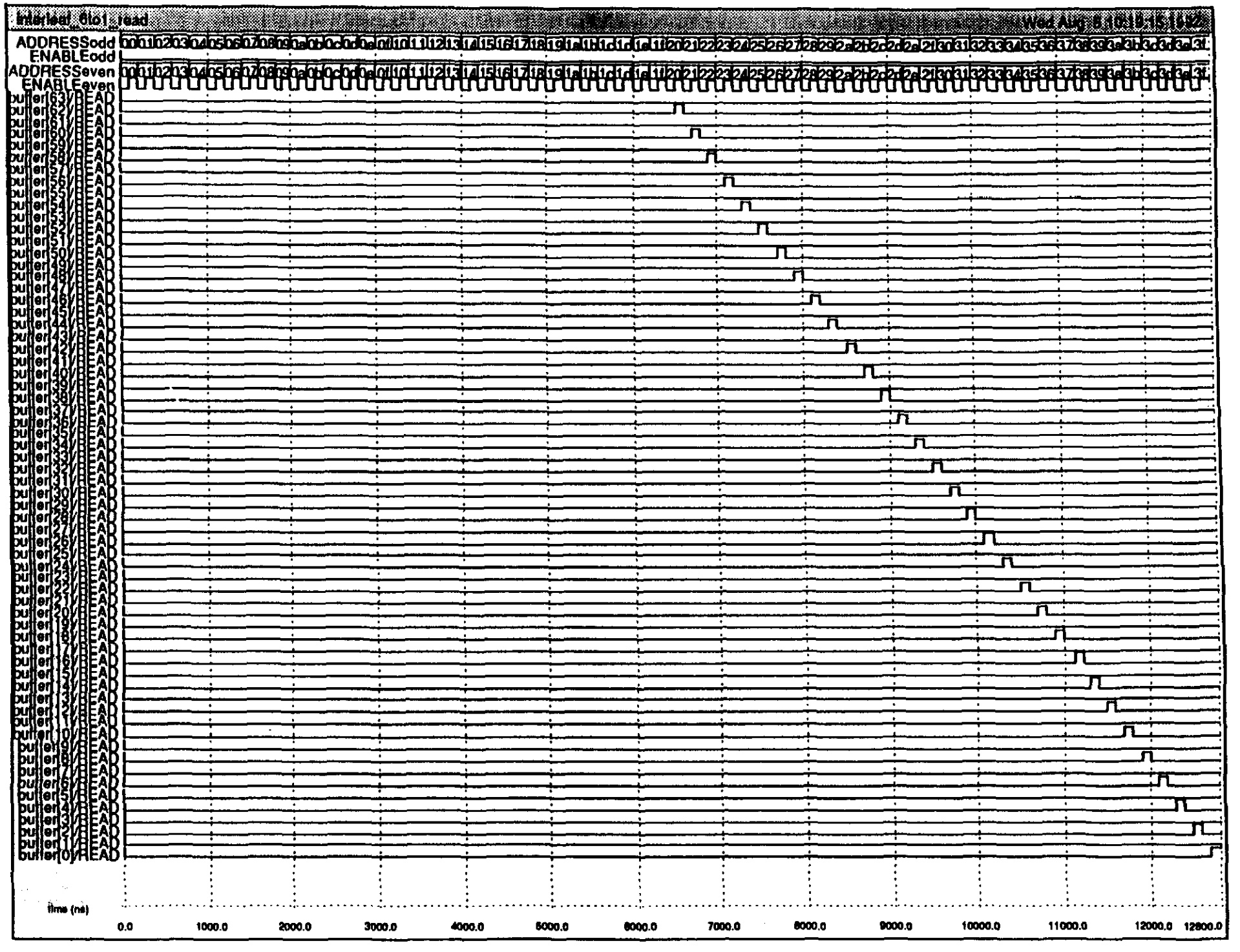
Integral linearity of VWCR, IPC5c, 425ns Tset (10 bit)





Title	IPC DECODER CELL	
Size A	Document Number	REV A
Date: September 2, 1992	Sheet 1 of 1	


decoder_6to1_read
Wed Aug 5 09:57:31 1992
ADDRESSodd
ENABLEodd
ADDRESSeven
ENABLEeven
buffer[63]/READ
buffer[62]/READ
buffer[61]/READ
buffer[60]/READ
buffer[59]/READ
buffer[58]/READ
buffer[57]/READ
buffer[56]/READ
buffer[55]/READ
buffer[54]/READ
buffer[53]/READ
buffer[52]/READ
buffer[51]/READ
buffer[50]/READ
buffer[49]/READ
buffer[48]/READ
buffer[47]/READ
buffer[46]/READ
buffer[45]/READ
buffer[44]/READ
buffer[43]/READ
buffer[42]/READ
buffer[41]/READ
buffer[40]/READ
buffer[39]/READ
buffer[38]/READ
buffer[37]/READ
buffer[36]/READ
buffer[35]/READ
buffer[34]/READ
buffer[33]/READ
buffer[32]/READ
buffer[31]/READ
buffer[30]/READ
buffer[29]/READ
buffer[28]/READ
buffer[27]/READ
buffer[26]/READ
buffer[25]/READ
buffer[24]/READ
buffer[23]/READ
buffer[22]/READ
buffer[21]/READ
buffer[20]/READ
buffer[19]/READ
buffer[18]/READ
buffer[17]/READ
buffer[16]/READ
buffer[15]/READ
buffer[14]/READ
buffer[13]/READ
buffer[12]/READ
buffer[11]/READ
buffer[10]/READ
buffer[9]/READ
buffer[8]/READ
buffer[7]/READ
buffer[6]/READ
buffer[5]/READ
buffer[4]/READ
buffer[3]/READ
buffer[2]/READ
buffer[1]/READ
buffer[0]/READ
time (ns)


interleaf_6to1_read
Wed Aug 8 10:19:15 1992
ADDRESSodd
ENABLEodd
ADDRESSeven
ENABLEeven
buffer63/READ
buffer62/READ
buffer61/READ
buffer60/READ
buffer59/READ
buffer58/READ
buffer57/READ
buffer56/READ
buffer55/READ
buffer54/READ
buffer53/READ
buffer52/READ
buffer51/READ
buffer50/READ
buffer49/READ
buffer48/READ
buffer47/READ
buffer46/READ
buffer45/READ
buffer44/READ
buffer43/READ
buffer42/READ
buffer41/READ
buffer40/READ
buffer39/READ
buffer38/READ
buffer37/READ
buffer36/READ
buffer35/READ
buffer34/READ
buffer33/READ
buffer32/READ
buffer31/READ
buffer30/READ
buffer29/READ
buffer28/READ
buffer27/READ
buffer26/READ
buffer25/READ
buffer24/READ
buffer23/READ
buffer22/READ
buffer21/READ
buffer20/READ
buffer19/READ
buffer18/READ
buffer17/READ
buffer16/READ
buffer15/READ
buffer14/READ
buffer13/READ
buffer12/READ
buffer11/READ
buffer10/READ
buffer9/READ
buffer8/READ
buffer7/READ
buffer6/READ
buffer5/READ
buffer4/READ
buffer3/READ
buffer2/READ
buffer1/READ
buffer0/READ
time (ns)
0.0
1000.0
2000.0
3000.0
4000.0
5000.0
6000.0
7000.0
8000.0
9000.0
10000.0
11000.0
12000.0
12800.0

To summarize the expected performance....

* Power dissipation ~ 10mW/channel

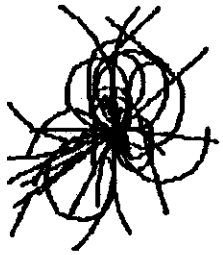
* We can make this 9-11 bit writing by adjusting the access time

* The droop rate is ~ 1.5mV/μs (2.5μs/bit)

* The 10-bit read time should be ~ 315ns

In summary

* We are almost ready to submit to Harris
* We have simulated out the wazoo, but continue
* The simulations appear to support a 10-bit memory
* We need to begin to converge towards a final configuration



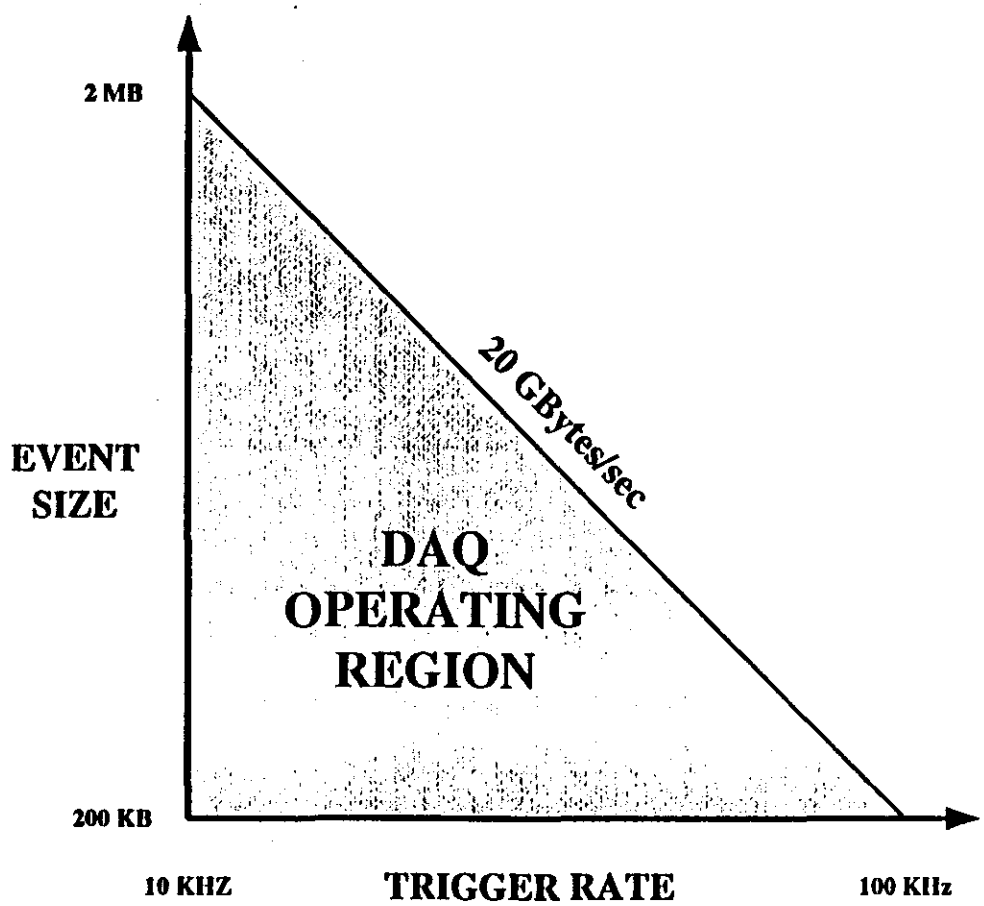
GEM - DAQ

MICHI BOTLO, MARK BOWDEN,
JHEROEN DORENBOSCH, VISHAL S. KAPOOR
& BEIBEI SHAO

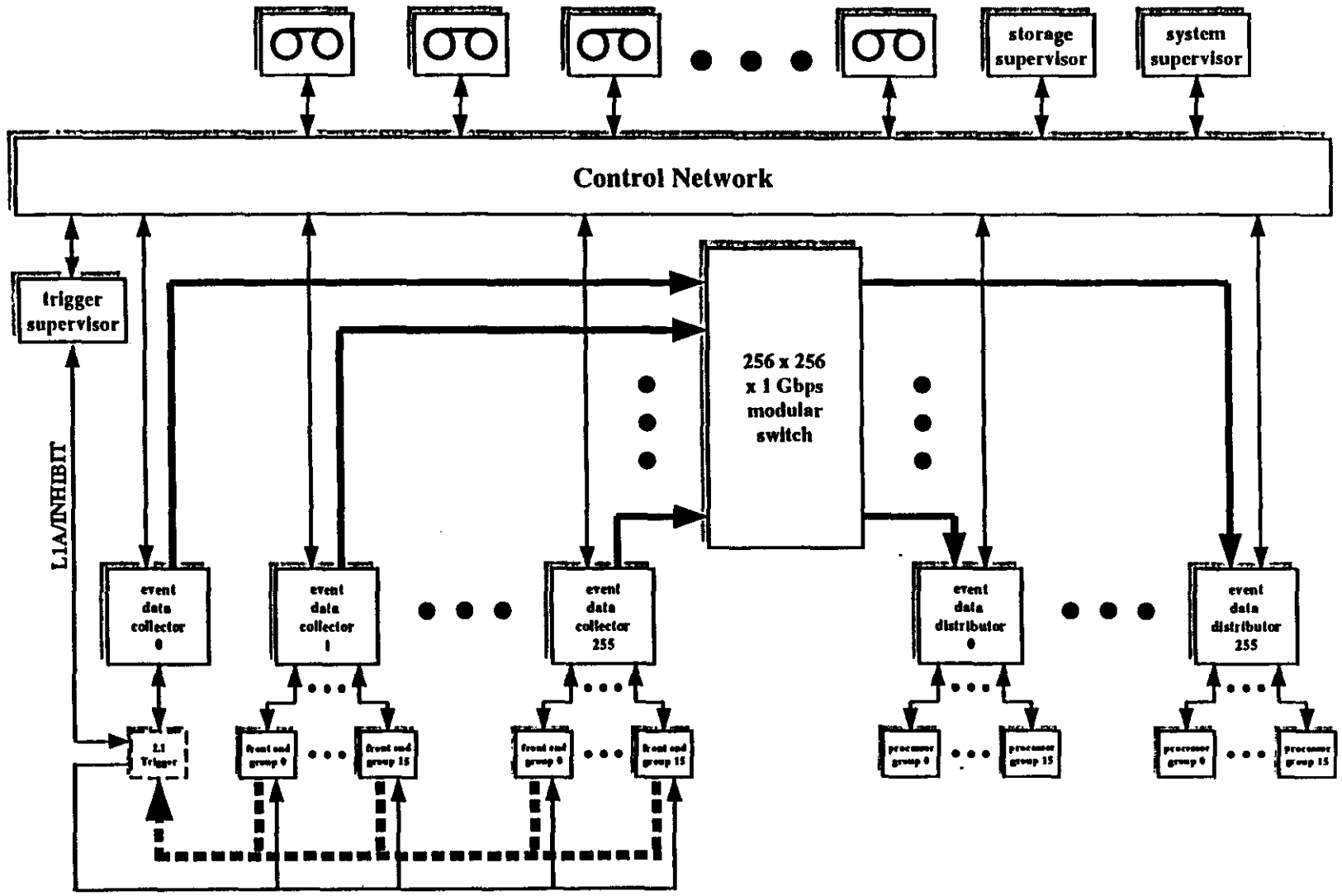
SUB-SYSTEM DATA RATES

SUB-SYSTEM	CHANNELS	EVENT SIZE	DATA RATE @100 KHz TRIGGER RATE
CALORIMETER	80 K	50 KB	5 GB/s
IPC	450 K	80 KB	8 GB/s
SILICON	3200 K	20 KB	2 GB/s
MUON	500 K	40 KB	4 GB/s

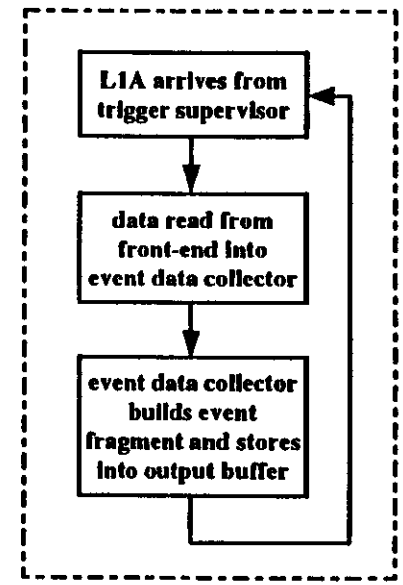
DAQ OPERATING REGION



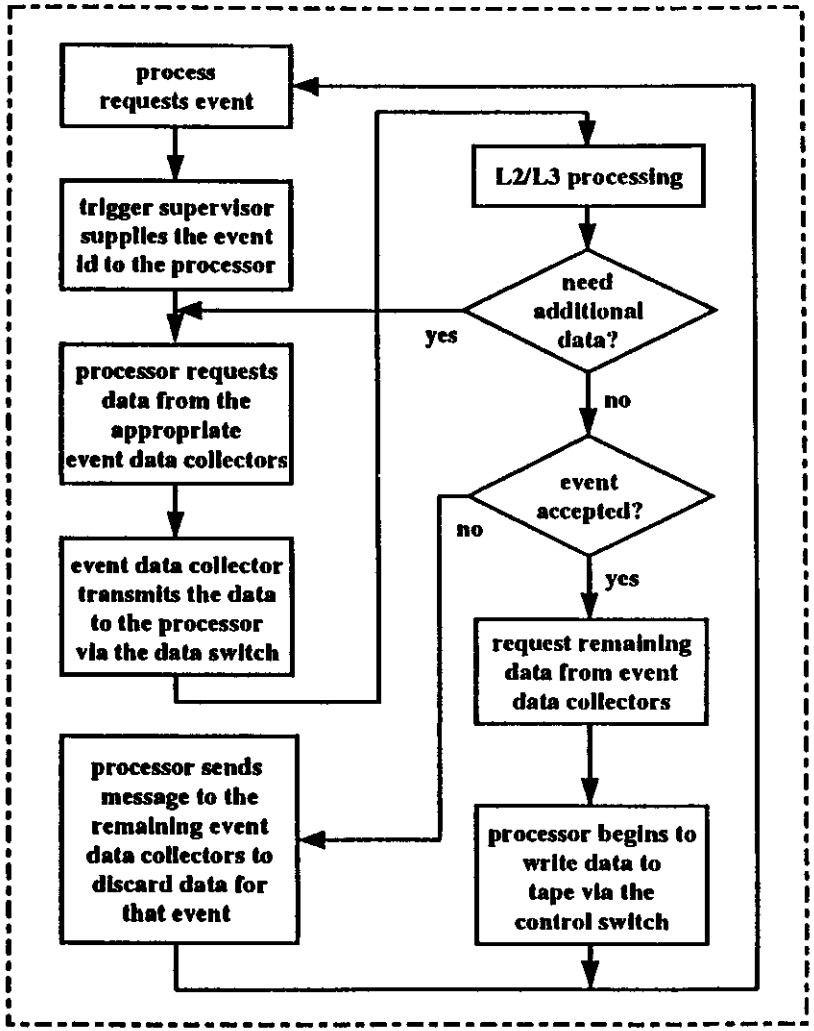
DAQ OVERVIEW



DATAFLOW OUTLINE

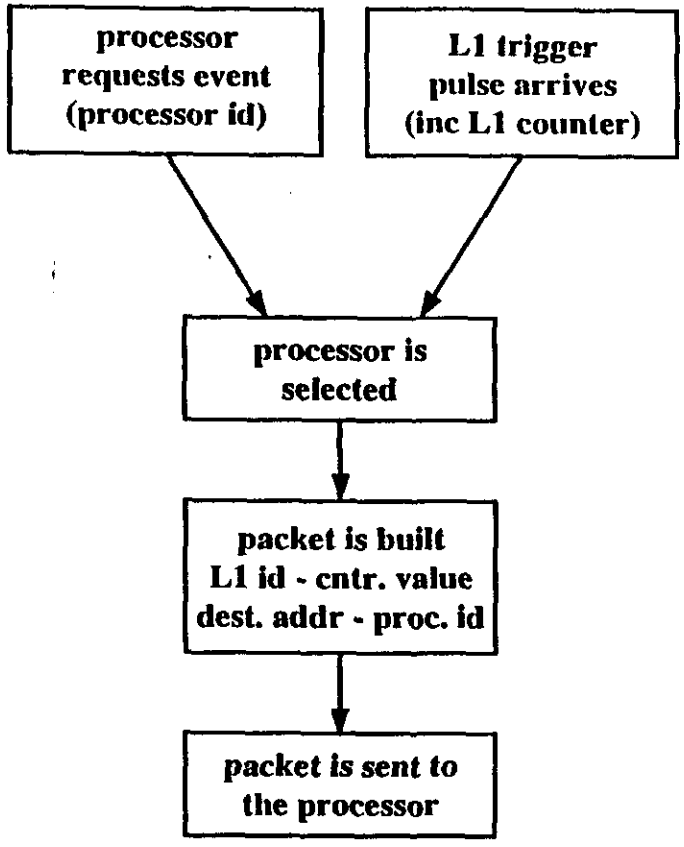


EVENT DATA COLLECTOR

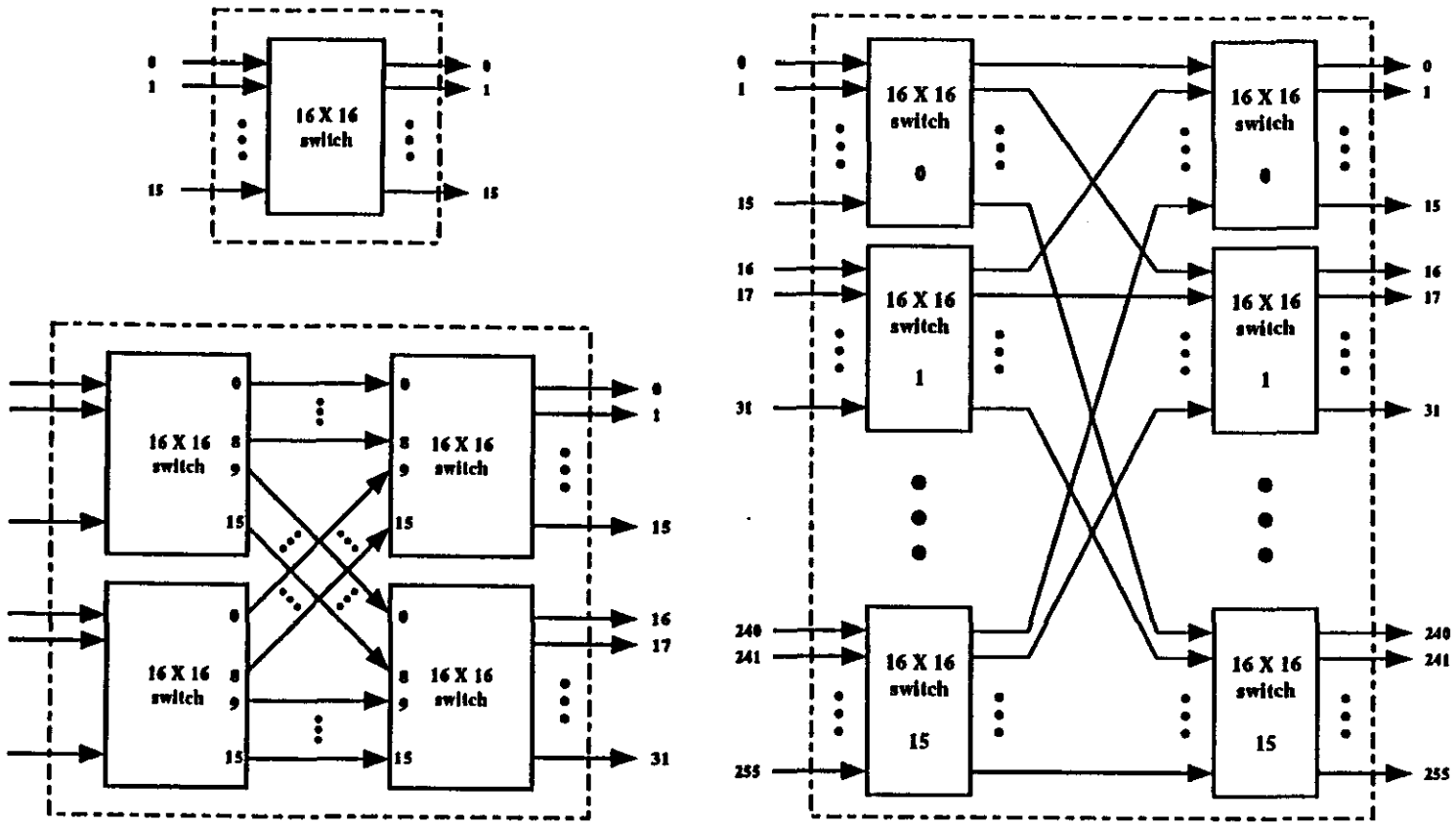


L2 PROCESS

TRIGGER SUPERVISOR

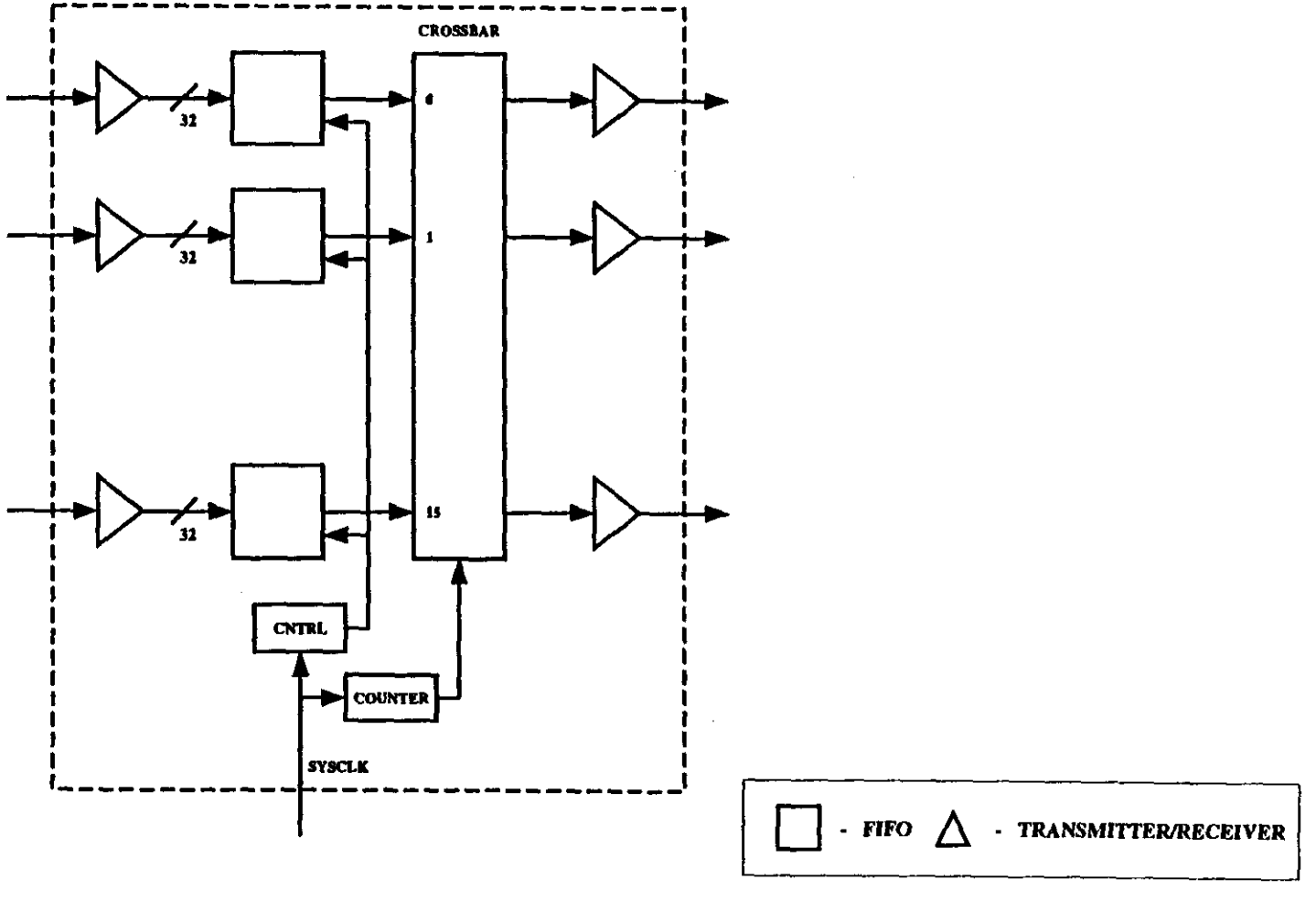


MODULAR SWITCH DESIGN

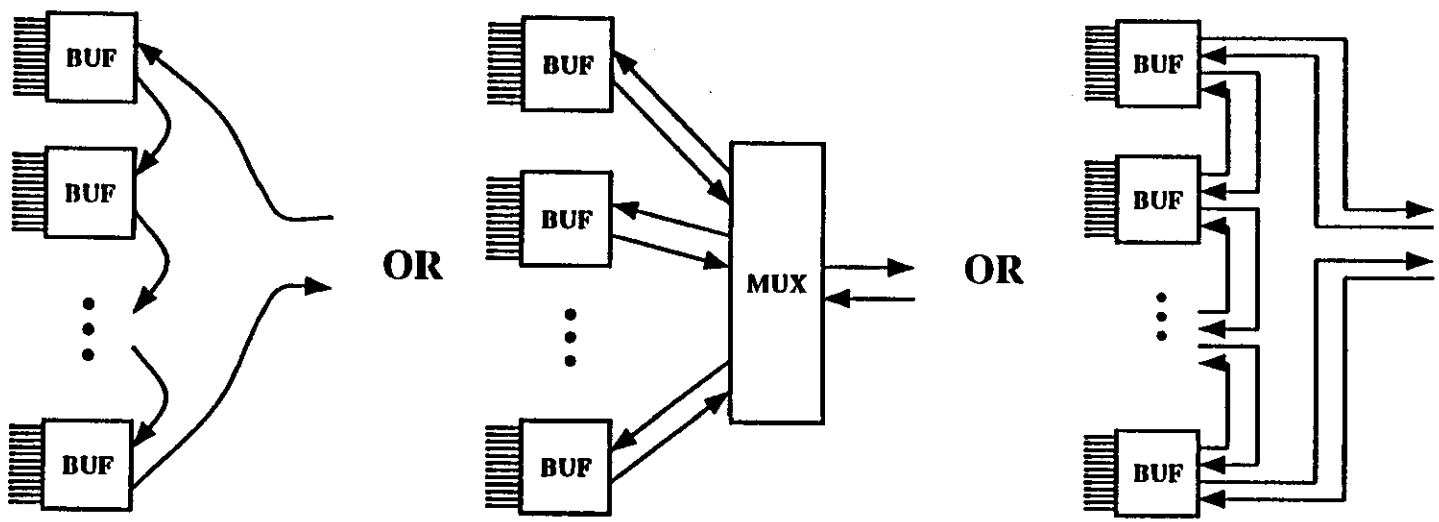


TIME DIVISION MULTIPLEXED SWITCH
(256 CHANNELS @ 1 Gbps)
IMPLEMENTING 65,536
VIRTUAL CHANNELS @ 4 Mbps

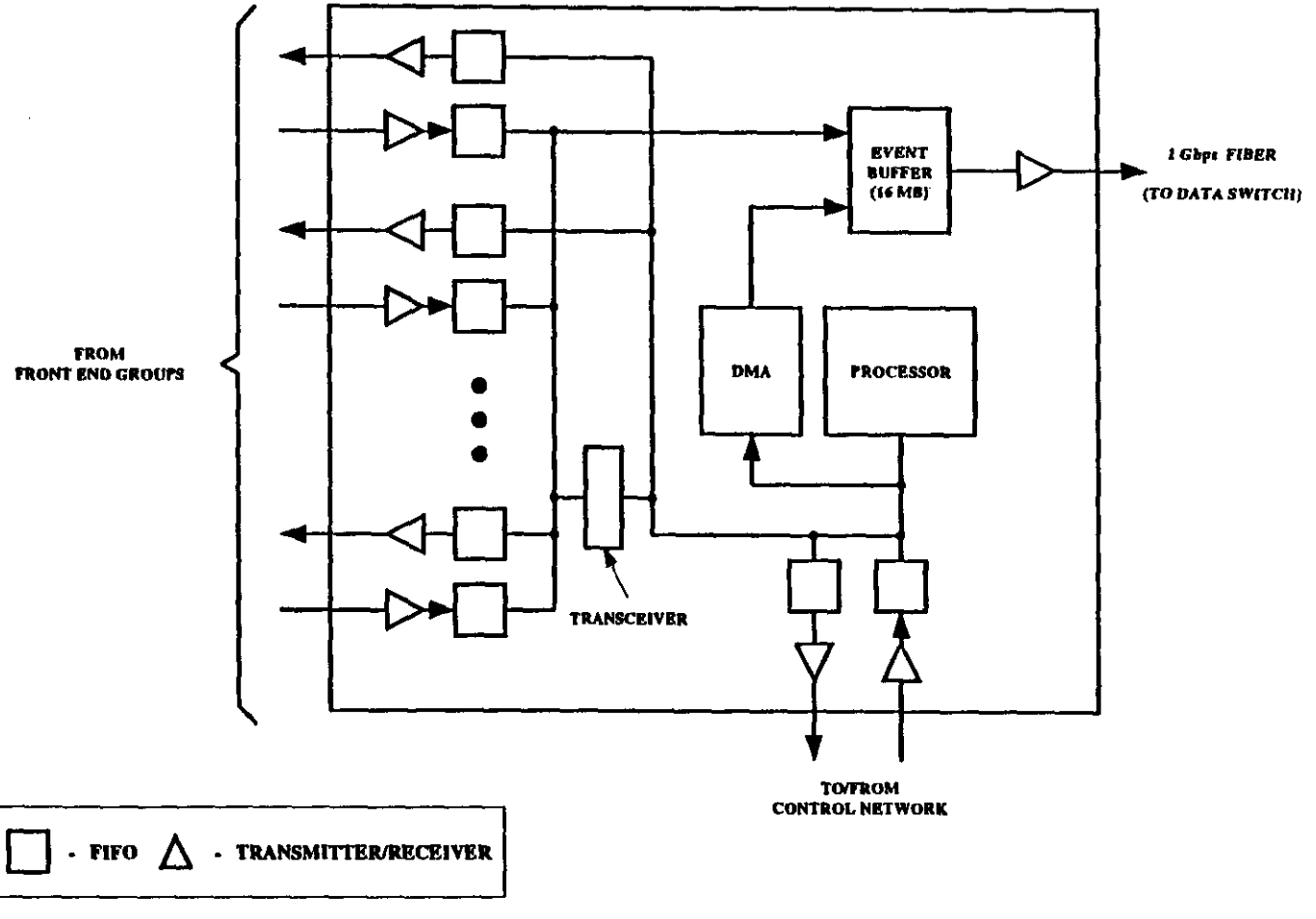
16 X 16 SWITCH MODULE



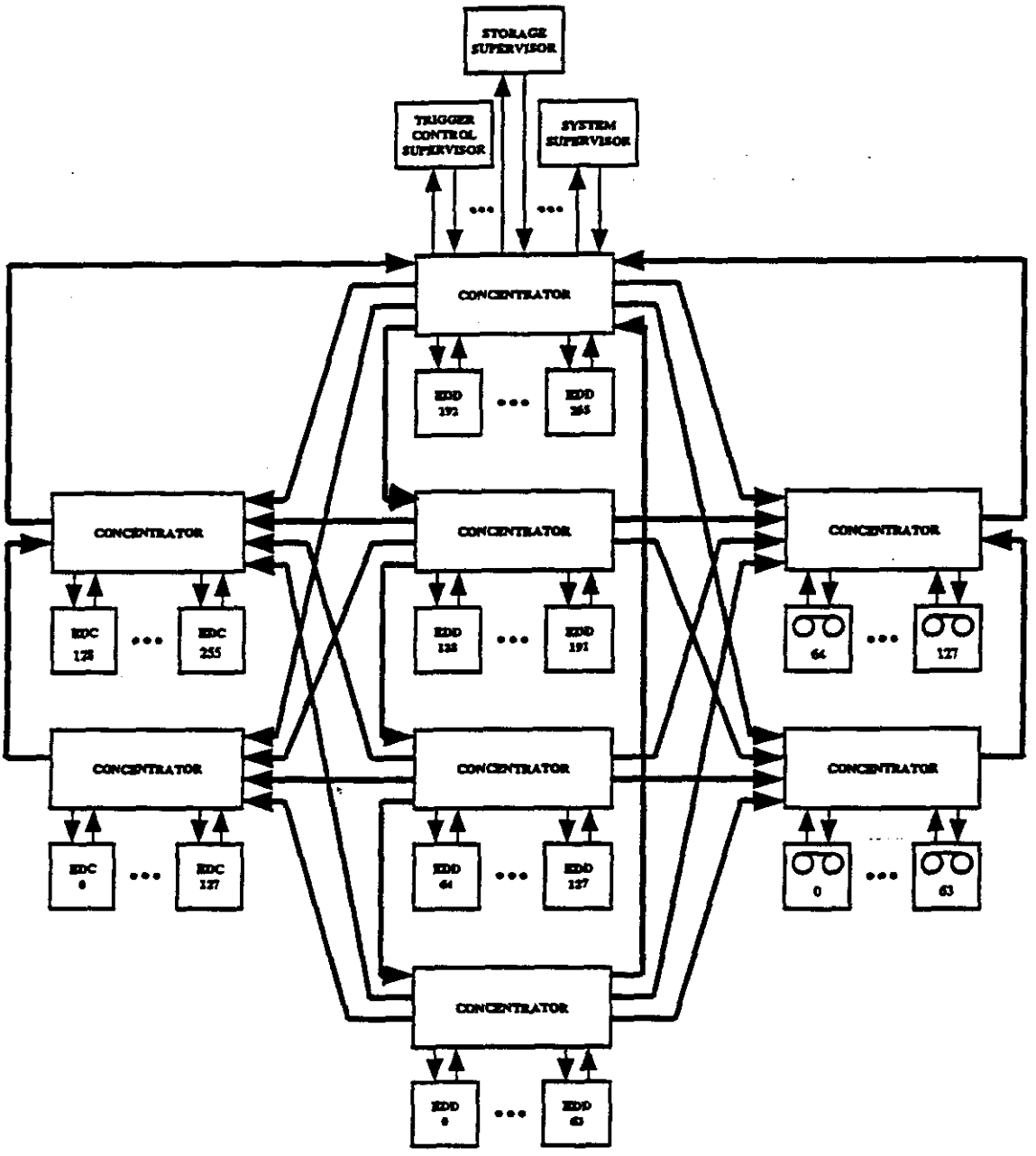
FRONT END GROUP



EVENT DATA COLLECTOR

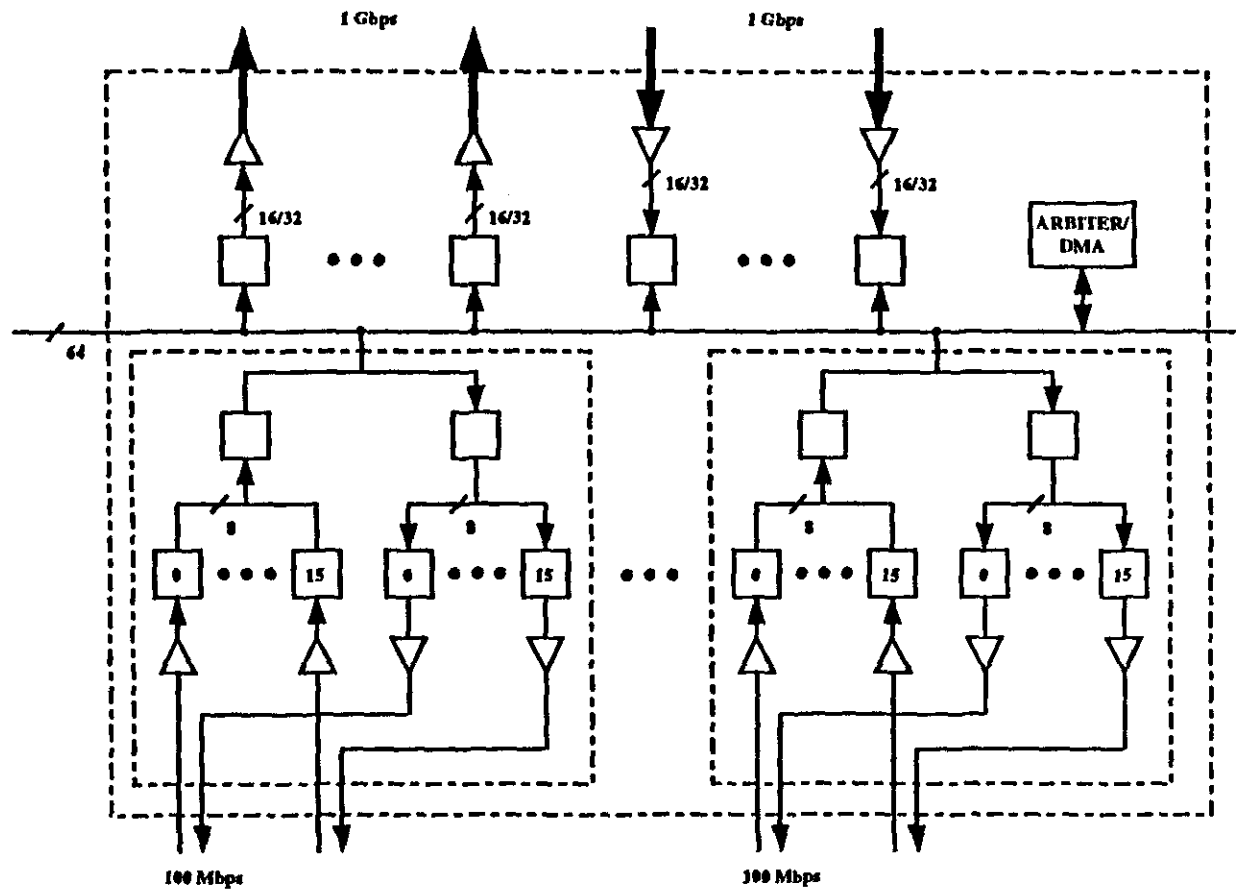


CONTROL NETWORK

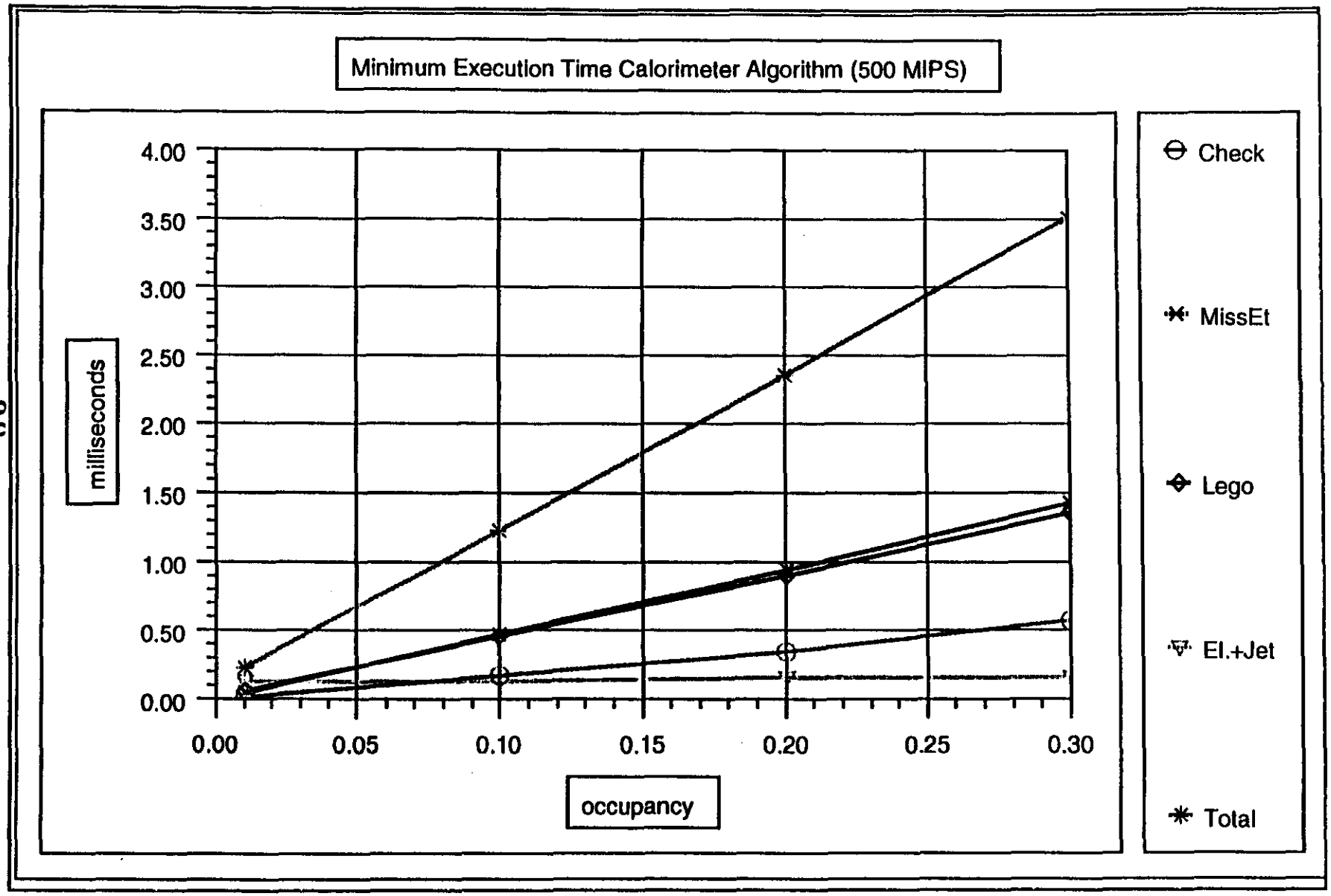


EDC - Event Data Collector
EDD - Event Data Distributor

CONCENTRATOR



□ - FIFO △ - TRANSMITTER/RECEIVER


Minimum Execution Time Calorimeter Algorithm (500 MIPS)
milliseconds
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0.00
0.05
0.10
0.15
0.20
0.25
0.30
occupancy
Check
MissEt
Lego
El.+Jet
Total