GEM TN-92-192

Muon Group Meeting - SSCL

September 2, 1992

Abstract:

Agenda, attendees and presentations of the GEM Muon Group Meeting held at the SSC Laboratory on September 2, 1992. Agenda items are: General Issues; Big Wheel Versus Sector Recommendation; Discussion of Recommendation; Engineering Input to Technology Decision; Status of Reports of R&D Efforts; Technology Decision Process; R&D for FY93; Electronics Issues; Report of Muon Neutron Committee; Update on Simulations; and Discussion/Review.

raft Agenda of 9/2/92 (Wednesday) GEM Muon Group Meeting: 10:30 AM to 6:00 PM

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1) General Issues: (Marx/Taylor) 10:30 AM - 11:00 AM
Short term goals and schedule

2) Big Wheel versus Sector Recomendation:
(Nimblett/Sawicki/Humphreys) 11:00 AM - 11:45 AM

3) Discussion of Recommendation (Group) 11:45 AM - 12:30 PM

unch

4) Engineering input to technology decision: 1:30 PM - 2:00 PM
(Marx and Group)
- uniform critique of alignment, manufactoring
- cost estimation

5) Status Reports of R&D efforts: 2:00 PM - 3:00 PM
(BRIEF update of progress and schedule)

- CSC-endcap (Whitaker)
- CSC-L angle (Prokofiev)
- CSC-UH (Lau)
- CSC-barrel (Atiya)
- RPC (Pless/Wuest)
- PDT (Bromberg/Miller)
- PDT-Dubna (Golutvin)
- LSDT (Osborne/Korytov)
- TTR status (Mitselmakher)

6) Technology Decision process: (Taylor and Group) 3:00 PM - 4:00 PM

7) R&D for FY93 (Mitselmakher and Group) 4:00 PM - 4:30 PM

8) Electronics issues: (Marlow/Atiya) 4:30 PM - 5:00 PM

9) Report of Muon Neutron Committee (Osborne) 5:00 PM - 5:15 PM

10) Update on simulations: (coordinated by McNeil/Yanagisawa/Dingus)

- hit level Monte Carlo 5:15 PM - 5:45 PM
- pattern recognition in CSC
- effect of dead 3 lamda
- background in EC (Ostopchuk)

11) Discussion/Review: (Group) 5:45 PM - 6:00 PM

Muon Subsystem meeting
@SSCL 9/2/92

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Technology Decision Process

F. Taylor

F. E. Taylor
9/2/92

STATUS OF GEM MUON SYSTEM

Issues:

- Big wheel or separate sector?
  - sectors slightly favored
  - finish analysis
    - bending of sector
    - cost of installation tooling
  - final recommendation by 10/1/92

- Which technologies?
  - chambers for tracking
  - alignment scheme
  - chambers for trigger
  - reports due 9/28/92
  - presentations 10/6/92

- R&D plan for FY93
  - organize by tasks not institutions
    - chamber R&D
    - chamber prototype fabrication
    - engineering support for chambers
    - TTR and test beam
  - first draft due 9/11/92
  - final draft due 10/1/92

- Engineering plan for FY93
  - tasks
    prototype support sector
    alignment technology
  - first draft due 9/4/92
  - final draft due 9/11/92

- Cost Revision and Schedule
  - due 10/30/92

- TDR writing
  - draft due early November
  - semifinal due 12/24/92
  - final due 1/31/93

Expect from this meeting:

- muon group input to Big Wheel vs Sector
- engineering input to technology decision
- review of detector R&D
  - description of what bringing to TTR
  - progress (only highlights please)
  - shipping schedule
- discussion of R&D plan
- update on simulations
  - what is needed for tech-decision
  - uninstrumented 3 λ in calorimeter
  - neutron backgrounds

Technology Decision Process:

- Appoint 3 to 4 outside reviewers
- Inputs
  - Proponent Reports due 9/28/92
  - Engineering Report due 9/28/92 will provide a uniform appraisal of alignment, mechanical design, costs
  - Comments of outside reviewers
- Open presentations 10/6/92
  - Each advocate 1hr talk 0.5 hr Q&A
- Muon Steering Committee meets with outside reviewers 10/6/92
- Steering Committee makes a rating morning10/7/92
- Rating presented to Muon Group afternoon 10/7/92.
- Collaboration Council Meeting 10/8/92
- Rating presented to GEM EC 10/8/92

Boundary Conditions:

- Rating made on 10/6/92 defines Baseline 2.

- Final decision follows TTR tests and completed FY92 R&D program.

- No new Chamber R&D funds until above are completed.

8/16/92

TO: GEM Muon Group
FROM: F.E.Taylor
SUBJECT: Summary of Discussion on 8/4/92 Pertaining to the Technology Decision

At the last GEM Muon Meeting held at the SSCL on 8/4/92, there was a discussion of the progress of the various technologies and the process by which the muon chamber technology decision will be made.

Each technology proponent was asked when and what will be delivered to the TTR for testing. The following is a summary of the discussion:

Technology	Chamber size	TTR delivery date
PDT - Dubna	1mx4mx8layers	7/28/92 delivered
PDT - MSU	1.29mx3.81mx4layers	9/11/92
LSDT	1mx4mx4layers	9/1/92
RPC	1mx2mx2layers	9/1/92
CSC - BU&BNL	0.6mx0.6mx4layers	8/25/92
CSC - UH	0.5mx1mx3layers	8/25/92
CSC - BU&BNL	1mx2mx4layers	10/15/92
CSC - Dubna	0.5mx4mx8layers	10/15/92

According to this schedule, the full-scale (defined as the size of a typical middle superlayer chamber) prototypes of the CSC technology will not be available for testing at the TTR until mid-October, past the October 7, 1992 deadline for the technology decision.

Given our baseline design, the questions we must answer are:

Barrel Issues:

(1) Which is the more attractive drift technology for the barrel - LSDT or PDT?
(2) Will the RPCs perform in terms of background sensitivity, time jitter, longevity, noise generation, multiple scattering ?
(3) In case the RPC are not accepted, is there an alternative trigger scheme for the drift technologies ? The burden of this question lies with the drift proponents.

Endcap Issue:

(1) Does the CSC technology work in the endcap environment as measured by the layer resolution, background sensitivity, trigger resolution and jitter, pattern recognition capability, and cost.

System Issues (Barrel and Endcaps):

(1) Will the CSCs work in the barrel? Cost and alignability are especially important in this question.

(2) Can the LSDTs be made to work in the endcaps with a trigger scheme which will operate in the high rate environment. Will the LSDTs live long enough in the high background environment?

At our meeting we discussed several ways to proceed:

(1) Make a crisp decision on October 7. The LSDT, PDT, and RPC technologies will be tested as full-scale prototypes, but the CSC decision will be made on the basis of a 0.6mx0.6m chamber (typical size of an endcap inner superlayer chamber). The verification of operation of the largest chamber (for the endcap 1.7mx3m - a scale-up factor of 3 in width and 5 in length) would have to be obtained later.

(2) Delay the decision until all full-scale prototypes are tested. This option will extend the R&D program as it is presently consituted by at least another 2 months (October and November). A stronger case for the decision would probably result, but would leave less time to fully engineer the new baseline for the TDR.

(3) Rate the technologies on October 7 and define the muon system baseline for concentrated engineering for the TDR. Maintain a committment to the most attractive alternative as a backup until approximately mid-November. Review the decision in approximately one month when the full scale CSC prototypes are tested.

I suggest that we proceed by Plan (3). Please make your opinion known if you have differences with this plan. We can discuss them at the next Muon Steering Committee meeting (suggested time - late afternoon September 3, 1992) and the Muon Meeting on Friday September 4, 1992.

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Memorandum

To: F. Taylor/M. Marx
From: R. Humphreys, C. Johnson, F. Nimblett and R. Sawicki
Subject: Engineering Evaluation of Muon Chamber Technology Options
Date: September 2, 1992

The effort to complete a mechanical engineering evaluation of the muon chamber technology options has commenced. Criteria have been developed to be used as a basis for evaluating the different options. These criteria are as follows

Design
- General design concept
- Weight
- Wire or strip support
- Gas systems
- Chamber structure
- Impact on truss structure design
- Superlayer configuration
- Electronic packaging requirements
- Size limitations
- Utility routing
- Failure tolerance

Manufacture/assembly
- Manufacturing approach/philosophy
- Component fabrication
- Precision requirements
- Manufacturing technology development requirements
- Vendor availability
- Assembly procedures
- Fixturing and tooling requirements
- Size limitations

Alignment
- Internal - wire/wire, plane/plane
- External - superlayer/superlayer
- Fiducialization

Structural performance
- Stiffness requirements
- Dimensional stability - thermal and vibration

Coverage
- Acceptance - phi and theta

Phi overlap potential

Cost

Assumptions, basis
Equipment, material and labor
Development, engineering, procurement/fabrication, and installation/assembly
Cost uncertainties

Schedule

Long lead components/material
Component fabrication time
Assembly time
Installation time
First availability

In order to complete the process in the short time available regular meetings will be held at the SSCL. The first meeting will be Sept 9 and 10. At this meeting each of the technology leaders must present all data available (in vugraph form) on the above listed subject matters. This information will be reviewed and evaluated. Areas that have not yet been addressed or need additional evaluation will be identified and resources assigned to complete the effort. Per your direction it is expected that C. Bromberg (PDT - Sept. 9 AM), L. Osborne (LSDT - Sept. 10 AM), S. Whittaker (CSC - Sept 10 PM) and C. Wuest (RPC - Sept. 15) will be present at this first meeting and provide the initial database of information for this evaluation. Subsequently, technology leaders must provide written reports which summarize their engineering design and will be used for the final evaluation report. This must be submitted by Sept 21 in order for the process to be completed by Oct. 1.

Follow-up meetings will be held according to the following schedule

Sept. 15	Status
Sept. 22	Draft reports due from technology leaders
Sept. 29	Review final report and appraisal

cc: M. Atiya
H. Baker
C. Bromberg
I. Golutvin
C. Johnson
M. Harris
K. Lau
M. Marx
G. Mitselmahker
L. Osborne
I. Pless
V. Polychronakos
S. Whittaker
C. Wuest

Big Wheel vs. Sectors

F. Nimblett

MUON SUPPORT STRUCTURE CONCEPTS

MODULAR

or

MONOLITHIC

?

STRUCTURE OPTIONS CONSIDERED

- **MODULAR (SECTOR)**
  With No Phi Overlap
- **MONOLITHIC (BIG WHEEL)**
  With No Phi Overlap
- **MODULAR**
  With Phi Overlap
- **MONOLITHIC**
  With Phi Overlap

CATEGORIES EVALUATED

- Structural Performance
- Coverage
- Alignment
- Prototyping
- Assembly
- Transportation
- Installation
- Facilities
- Cost
- Schedule

RECOMMENDATIONS

- Recommendation to proceed with Modular Support Stucture concept should be "Preliminary" pending additional information with a Final Recommendation due on 01 October '92.
- Complete work on vibration analysis of Modular and Monolithic Structure option to determine effects on performance.
- Continue efforts on costing of support equipment to validate costs and procedures for assembly and installation for both Modular and Monolithic Support Structures.
- Continue work on Phi Overlap Options to better understand effects on alignment and technology options.
- Consider structure options for the endcap as well which is currently configured as being assembled on the surface with no designation of structure type.

CSC Effort

M. Marx

Mike Marx 9/2

Joint Venture - Geography / Technology

- BNL, BU, UH, ITEP, JINR, MEPI, (MIT), PNPI, PU, SB, SSCL

Joint Document - Ends + Barrel

Joint M.C. - Lorentz, Parameters .....

(Chernyatin, Mitselmakher, Polychronakis .....

- Environment

(Ostapchuk, Yanagisawa .....

(Osborne ....

Prototypes - UH $3g \times .5 \times 1m^2$ 9/15

BNL $2 \times 4g \times .6 \times .6 m^2$ 9/15
$4g \times 1 \times 1.8 m^2$

BU $2 \times 4g \times .5 \times .6 m^2$ 9/16

JINR $2g \times 1.1 \times 1.5$ 9/28 +

R+D plan for FY93

CSC Meeting Tonite 8PM

RPC

I. Pless

MUON MEETING
SSC 2 SEPT 1992
I. A. PLESS

R AND D TO DATE — RPC

1. CONSTRUCTED GLASS RPCs

2. TESTED ITALIAN 1METER X 2METER RPC

3. DESIGNED STRUCTURE

4. TESTED NEUTRON SENSITIVITY

5. DEVELOPED RATE CRITERIA

6. CURRENT R AND D EFFORTS

1. GLASS RPC

CONSTRUCTED SIX GLASS RPCs
TESTED EFFICIENCY AND STRIP
PICK UP TECHNIQUES.

MAIN RESULTS:

MEASURED BULK RESISTIVITY $\cong 5 \times 10^{12}$ OHM-CM

MEASURED EFFICIENCY $\cong 75\%$

MEASURED PLATEAU $\cong$ 1,500 VOLTS
MEASURED KNEE $\cong$ 6.5 KILOVOLTS
MEASURED RISE TIME JITTER $\cong$ 5 NANOSECONDS

WE COMPLETELY UNDERSTAND THESE RESULTS
AND HAVE A RSI / NIM PAPER IN PROGRESS

ITALIAN $1 \times 2 = (M)^2$ RPC TEST

1. EFFICIENCY $\geqq$ 96 %

2. RISE TIME JITTER $\leq$ 1.4 NANOSECONDS

3. PLATEAU $\cong$ 1,000 VOLTS

4. KNEE $\cong$ 6.5 KILOVOLTS

THIS DESIGN HAS BEEN USED IN EXPERIMENTS IN EUROPE AND THE U.S.

THE DESIGN IS SIMPLE AND THE RPC IS EXTREMELY RUGGED, NOT AT ALL DELICATE.

QUOTED RATE CAPABILITY $\cong$ 50 HERTZ/CM^2

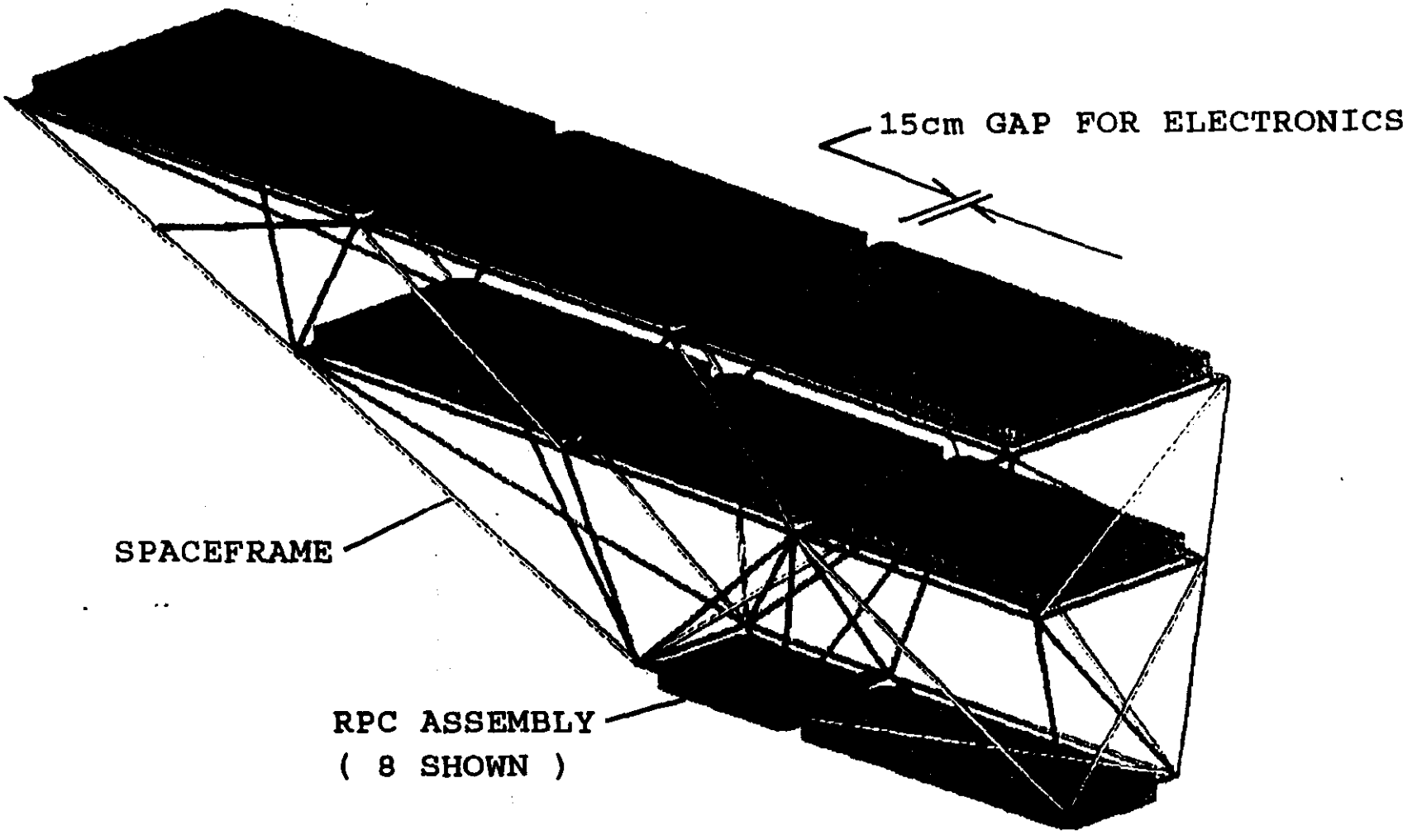
BULK RESISTIVITY $\cong$ 1.5×10^{11} OHM·CM

WE UNDERSTAND THESE RESULTS COMPARED TO THE GLASS RPC. THIS UNDERSTANDING WILL BE INCLUDED IN OUR RSI/NIM PAPER.

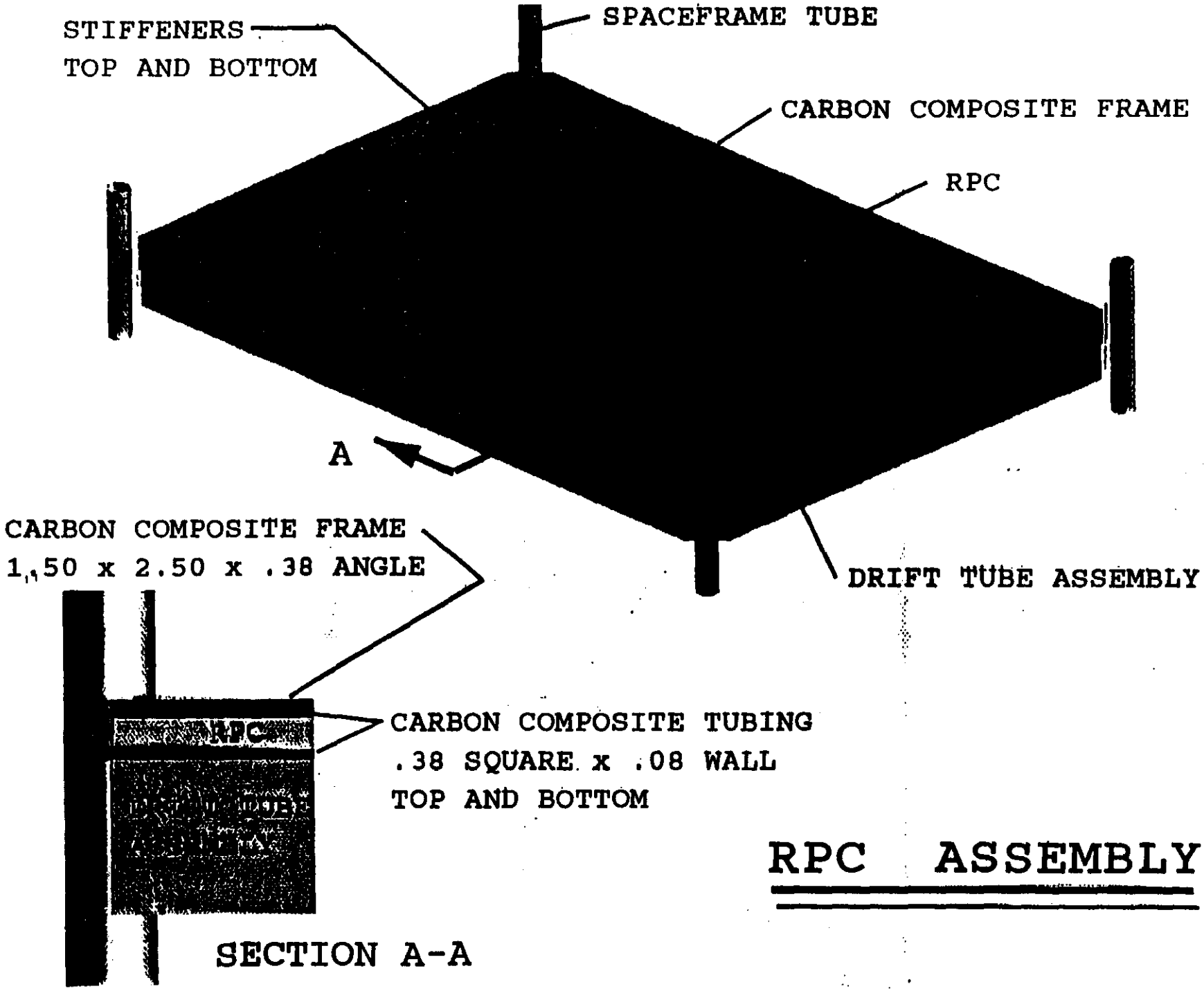
STRUCTURE DESIGN
LLNL - C. WOEST

A STUDY OF A RPC SYSTEM HAS BEEN MADE. THIS IS SHOWN IN THE NEXT TWO VIEW GRAPHS

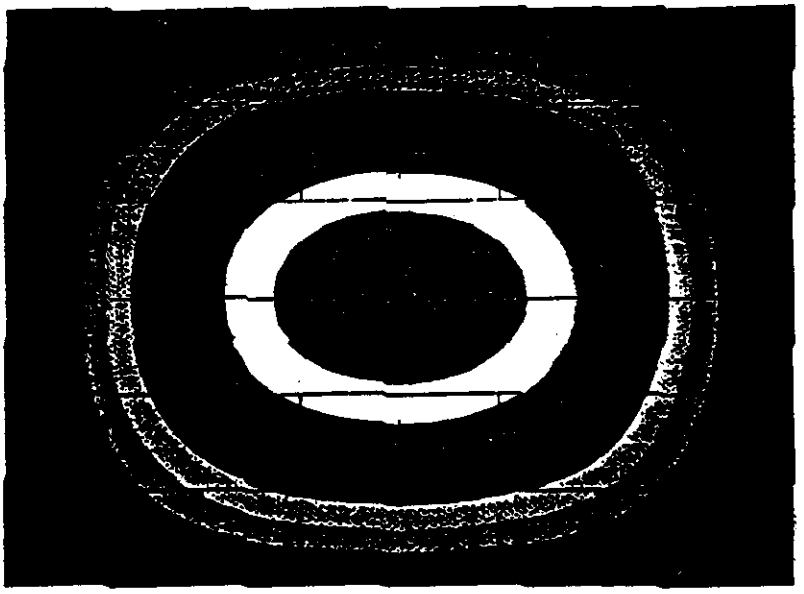
A STUDY OF THE SAG OF A TWO LAYER RPC UNDER IT'S OWN WEIGHT HAS ALSO BEEN MADE. THIS IS SHOWN IN THE THIRD VIEW GRAPH



MUON SEGMENT



RPC ASSEMBLY



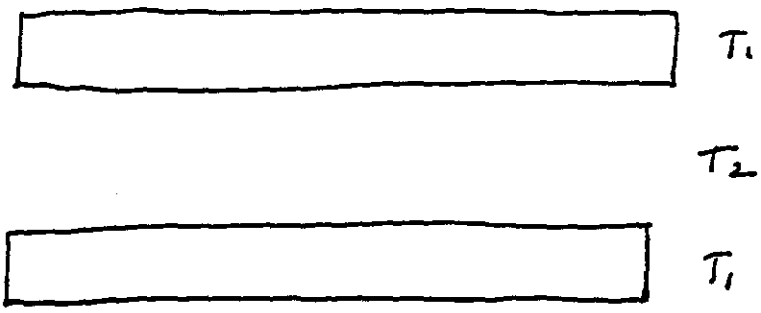
NEUTRON SENSITIVITY

WE HAVE EXPOSED THE ITALIAN RPC TO A NEUTRON SOURCE. WE HAVE MEASURED THE SENSITIVITY OF THE ITALIAN RPC TO SLOW NEUTRONS. THE SENSITIVITY IS ABOUT 5×10^{-3} PER NEUTRON.

THE RESULTS OF THIS TEST WILL BE INCLUDED IN THE RSI/NIM PAPER.

RATE CRITERIA

WE HAVE DEVELOPED A FORMULA FOR THE RATE CAPABILITY OF A RPC.



ρ = RESISTIVITY

ϵ = DIALECTRIC CONSTANT OF MATERIAL $\cong 5$

ϵ_0 = DIALECTRIC CONSTANT OF GAS $= 1$

$$\text{RATE} = K \frac{1}{\rho T_1} \frac{2 T_1 \epsilon_0 + T_2 \epsilon_1}{\epsilon_1 \epsilon_0}$$

FOR SMALL T_1

$$\text{RATE} \cong \frac{T_2}{T_1} \frac{1}{\rho}$$

CURRENT: R AND D

1. INCREASE RATE CAPABILITY TO ONE KILO HERTS/CM²

   A. REDUCE BAKELITE THICKNESS BY FACTOR 6

   B. REDUCE RESISTIVITY BY A FACTOR 2

WE HAVE THIS MATERIAL IN HAND AND ARE CONSTRUCTING SUCH AN RPC TODAY.

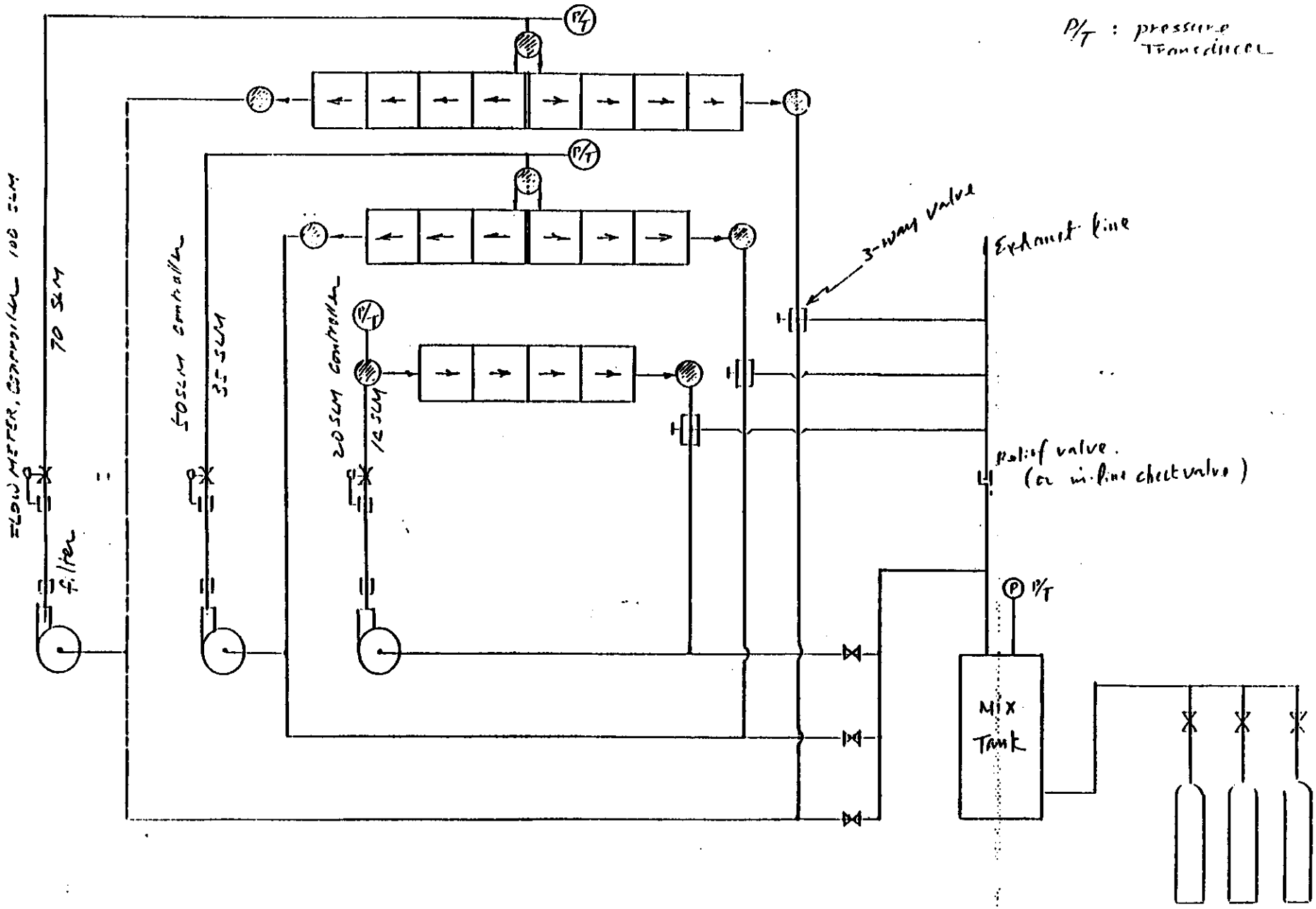
THIS SHOULD HAVE A RATE CAPABILITY OF 600 – 1000 HERTZ/CM²

WE ARE CONCENTRATING ON LOWER RESITIVITY MATERIALS.

<u>NOTE</u>: THE FACTOR OF 6 IN THICKNESS REDUCES THE TWO LAYER RPC RADIATION LENGTH FROM 3% TO 0.5%.

Material	*Thickness (cm)*	*Bulk resistivity(Ω·cm)*	*Arc resistivity(Ω·cm²)*
phenolic	.161	4.5×10^{9}	7.24×10^{8}
mirrored glass	.066	4.9×10^{12}	3.23×10^{11}
mirrored glass	.0250	———	———
borosilicate glass	.0762	7.5×10^{13}	5.72×10^{12}
ABS plastic	.077	2.37×10^{14}	1.83×10^{13}
Kodak projector glass	.123	6.42×10^{11}	7.89×10^{10}
cellulose acetate	.023	4.63×10^{14}	1.07×10^{13}
mica	.010	5.1×10^{14}	5.10×10^{12}
Stat-Loy P plastic	.323	1.4×10^{10}	4.52×10^{9}
Mitech-411 plastic	.090	2.03×10^{9}	1.83×10^{8}
Abstat-310 plastic	.072	5.78×10^{9}	4.16×10^{8}
Corning 7059 glass	.0122	1.6×10^{11}	1.95×10^{9}
Corning 0211 glass	.056	6.7×10^{7}	3.75×10^{6}
soda lime glass	.077	6.00×10^{11}	4.62×10^{10}

NATIONAL 42-182 100 SHEETS

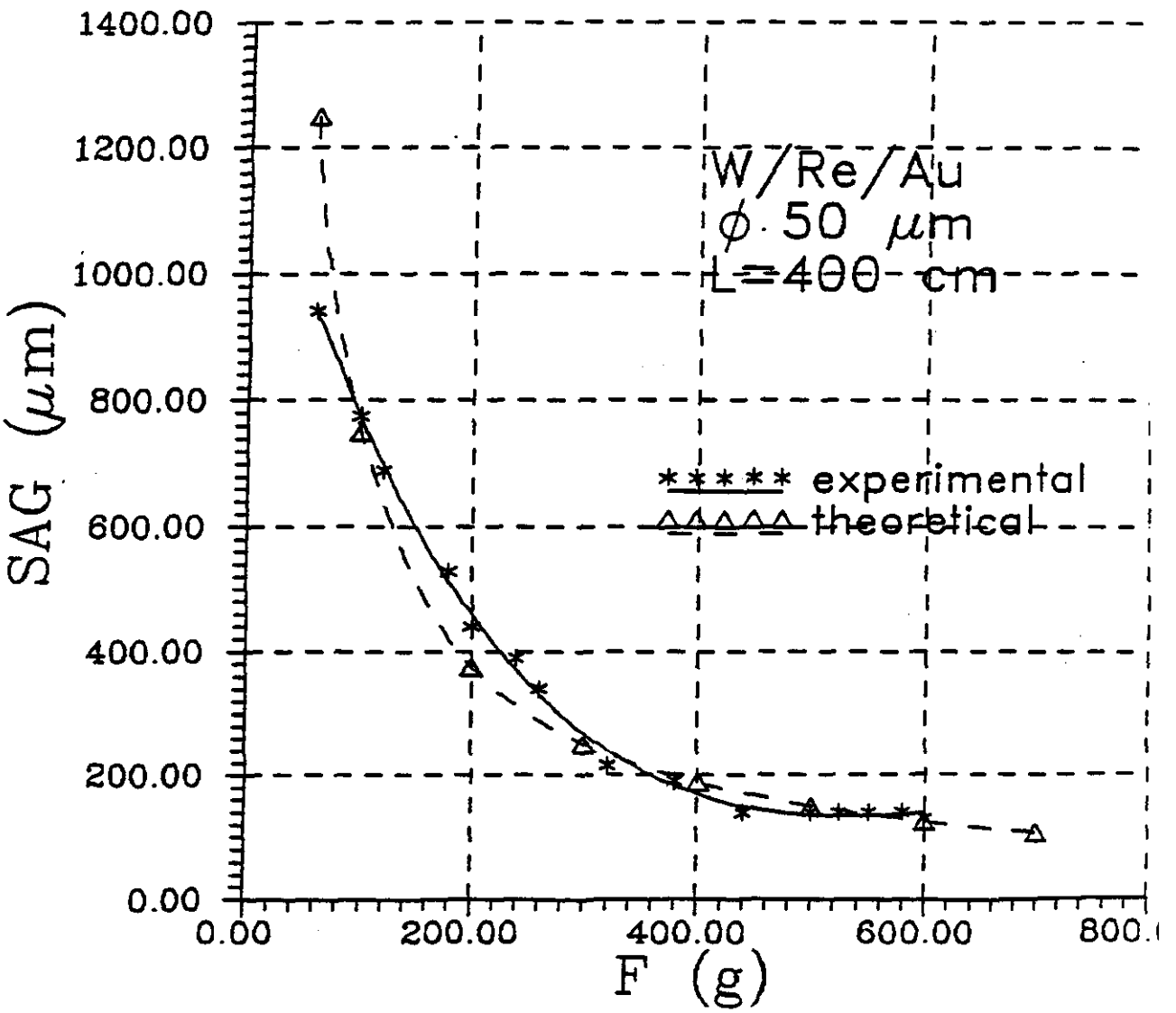


Dubna PDT

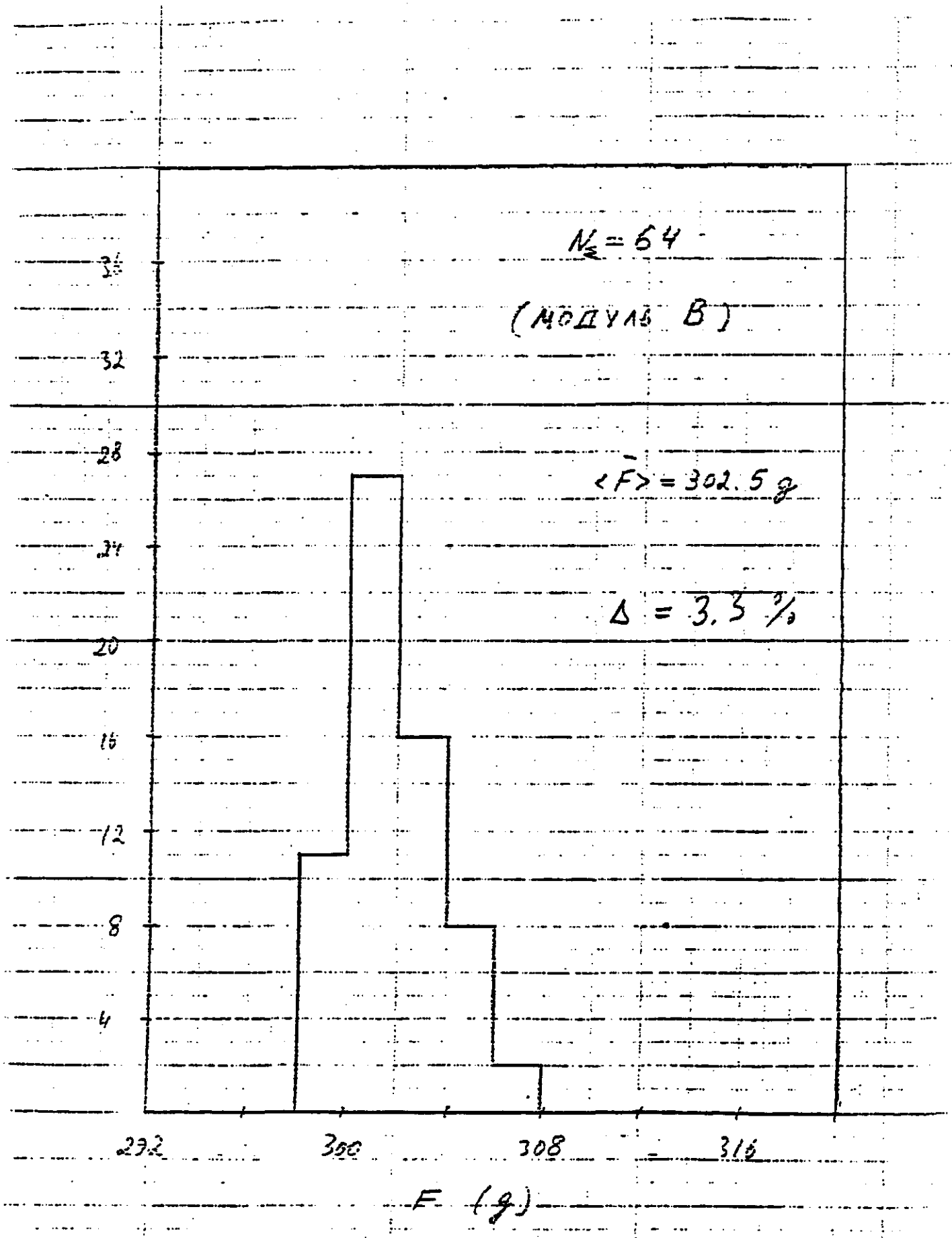
I. Golutvin

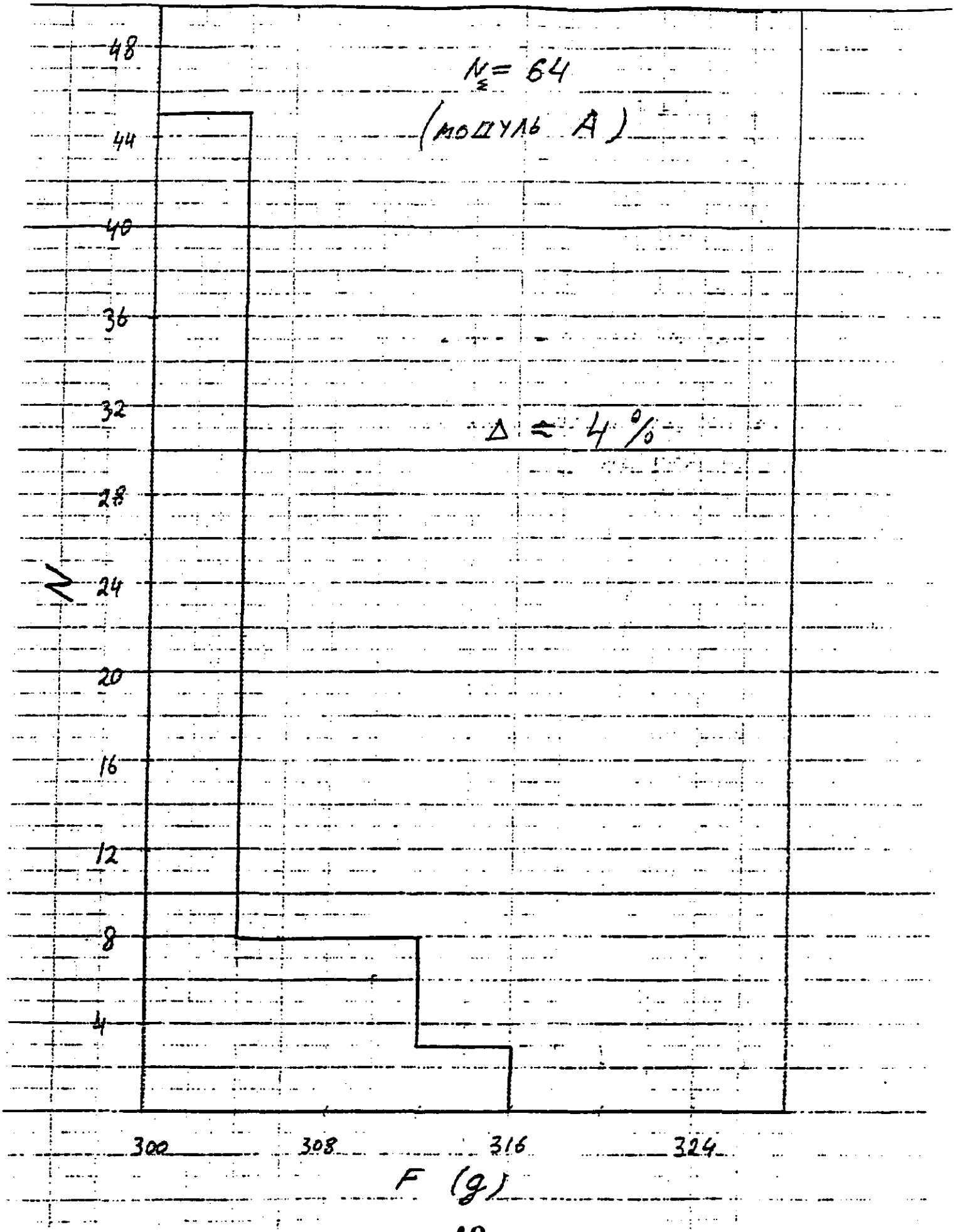
I. GOLUTVIN

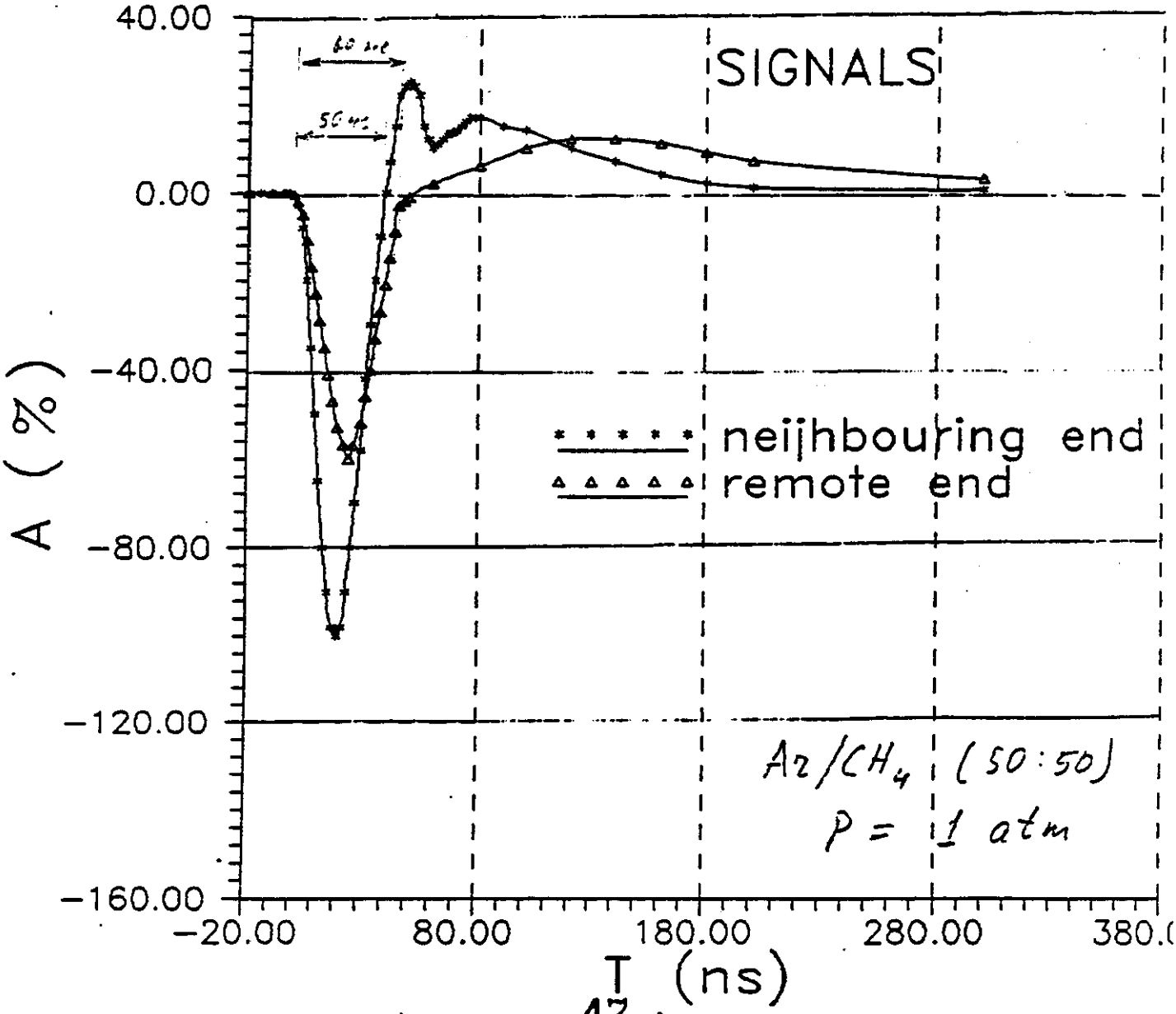
DUBNA PDT MODULE STATUS

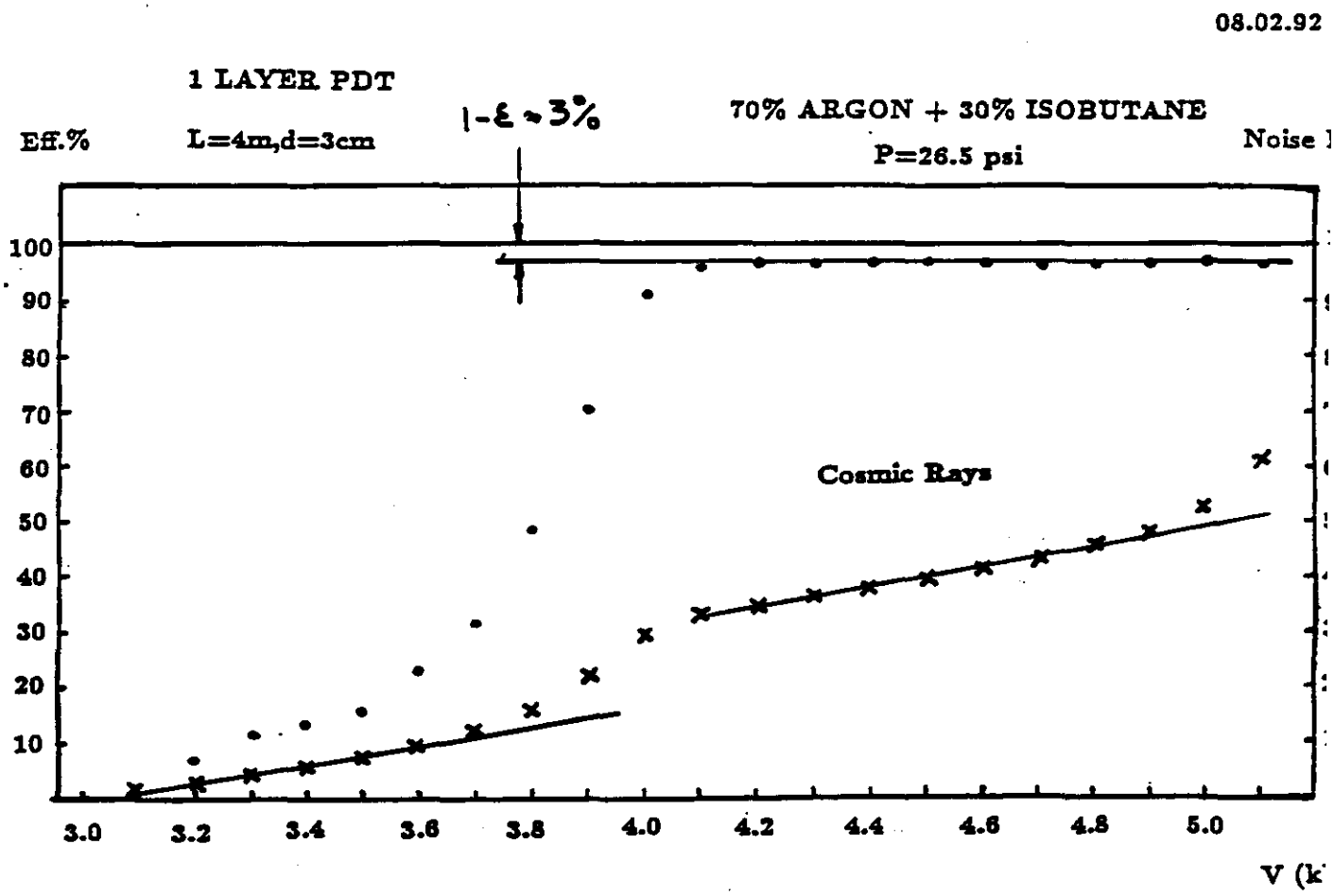


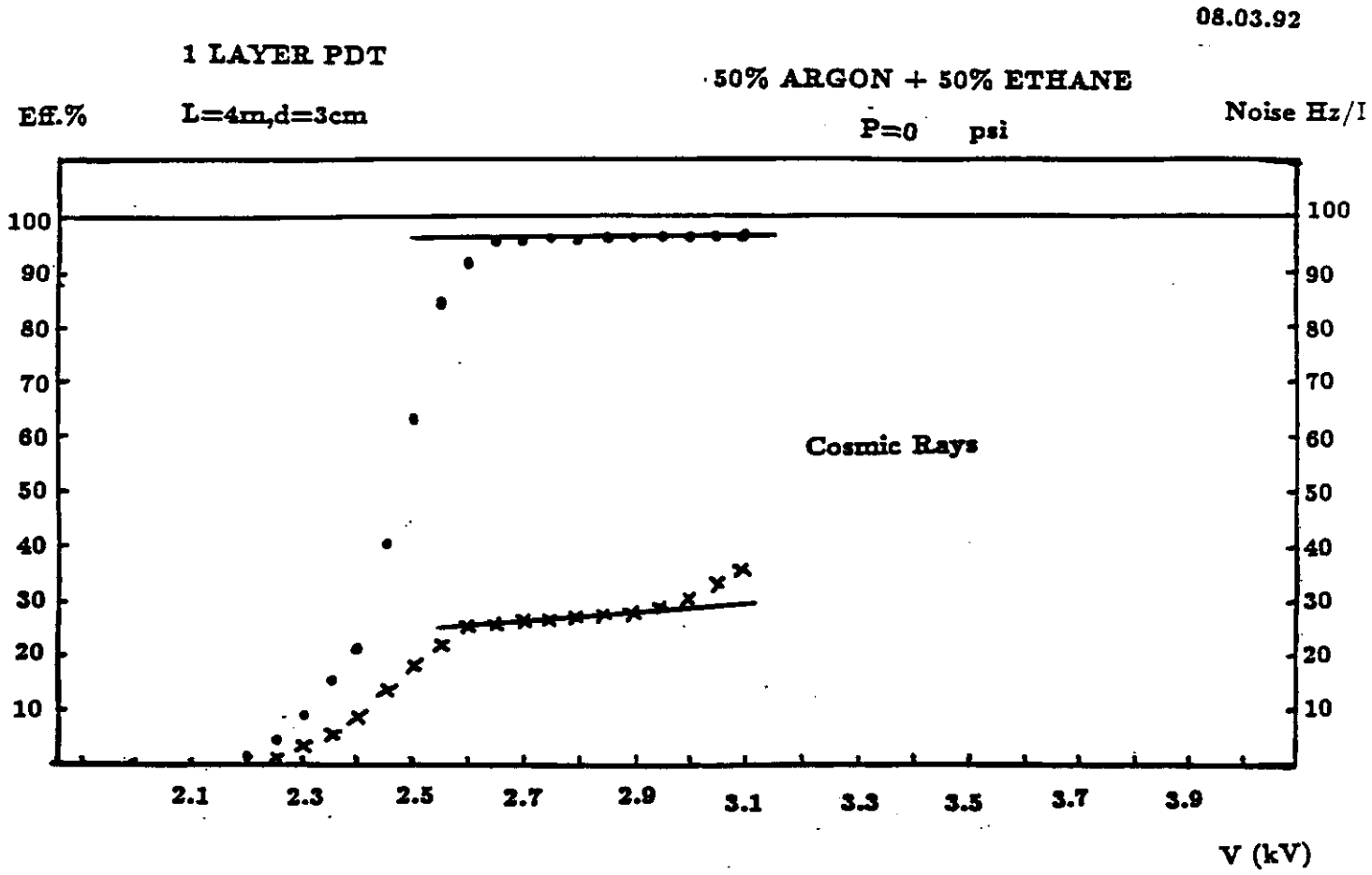
гравитационное смещение с коррекцией данных
(+40μm за счет прогиба капроновой нити Ø 75μm)


N = 64
(МОДУЛЬ В)
<F> = 302.5 g
Δ = 3.3 %
36
32
28
24
20
16
12
8
4
292
300
308
316
F (g)

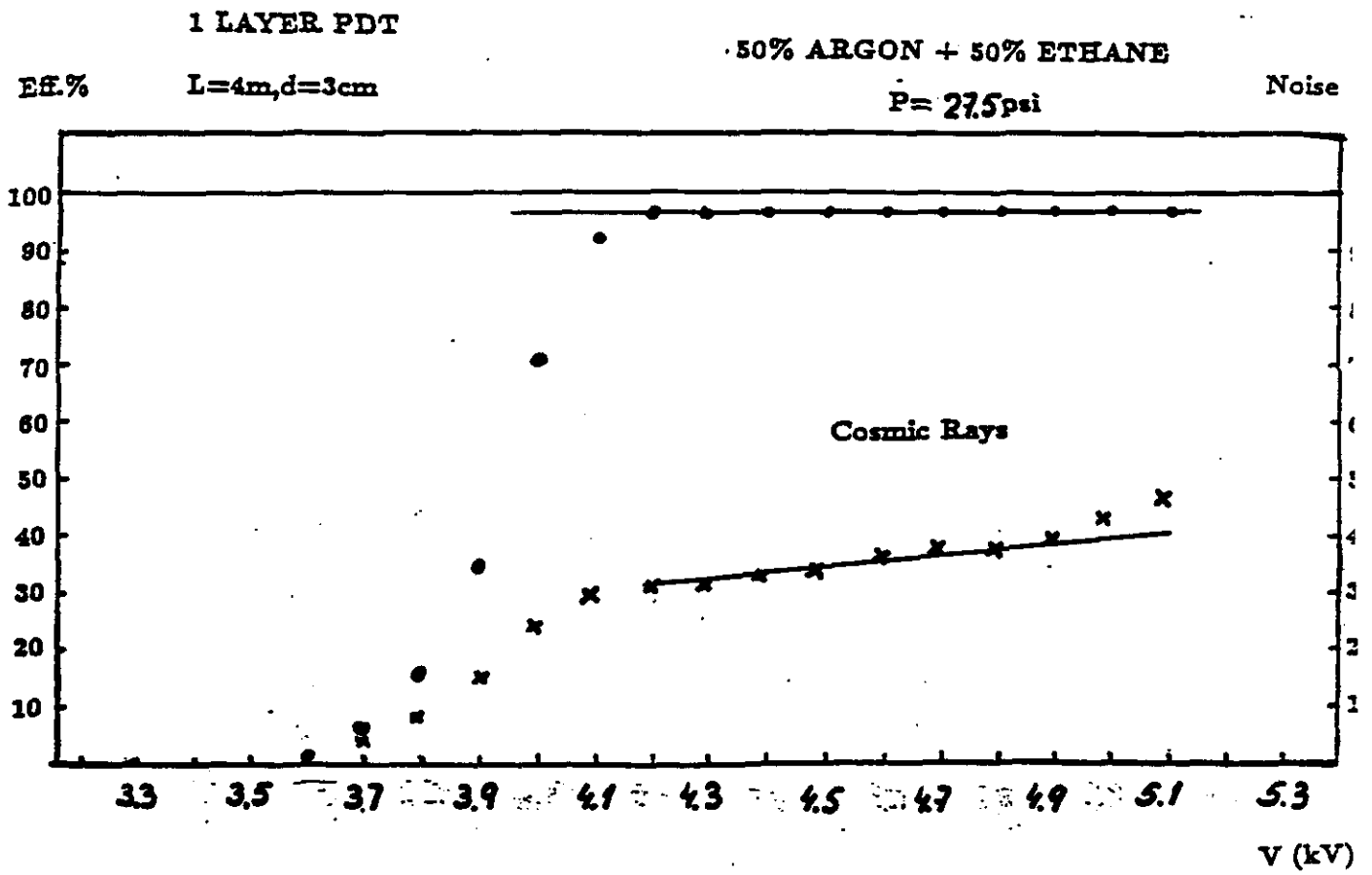

N = 64
(МОДУЛЬ А)
Δ ≈ 4 %
N
48
44
40
36
32
28
24
20
16
12
8
4
300
308
316
324
F (g)

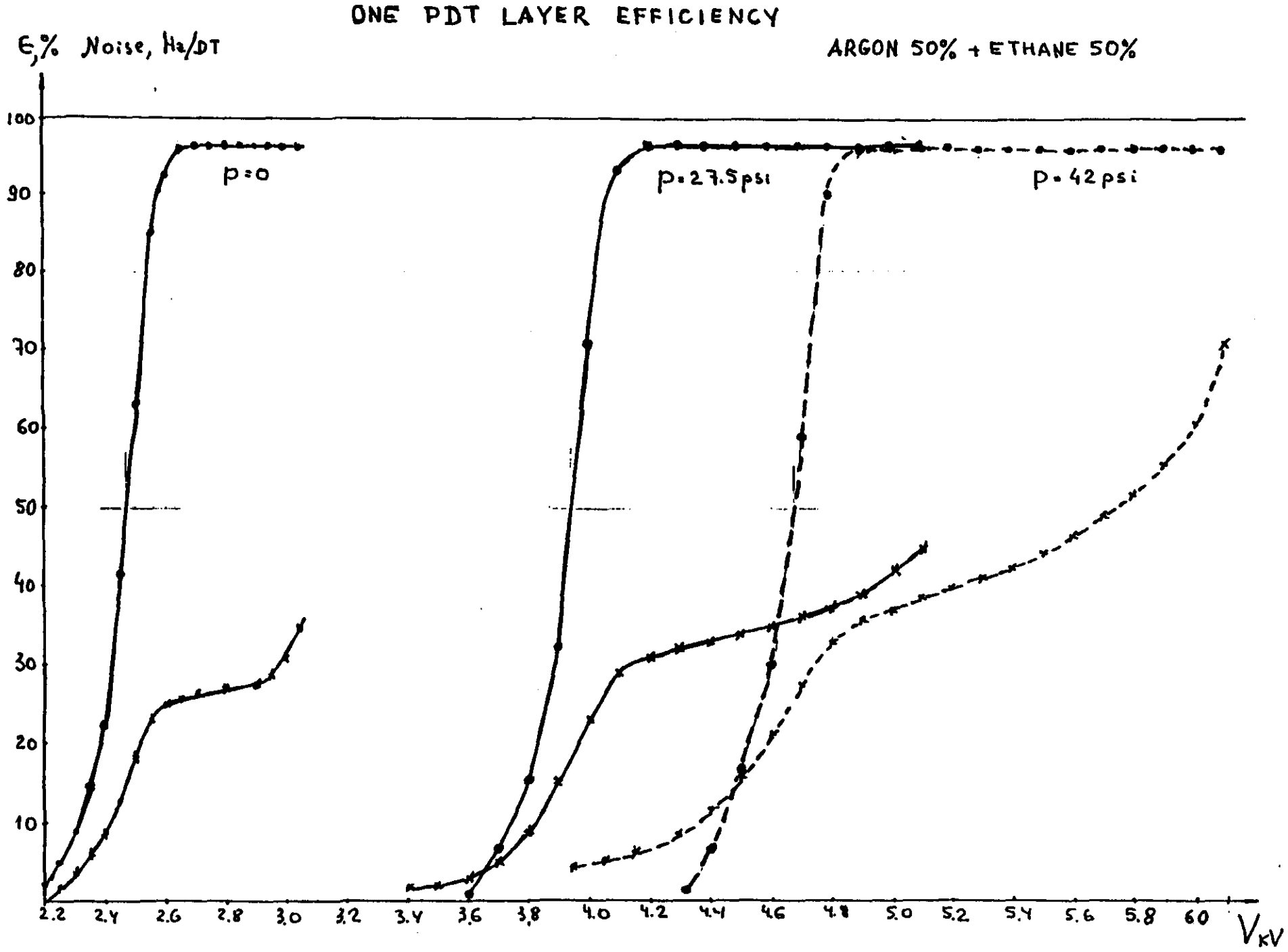

SIGNALS
neijhbouring end
remote end
Ar/CH4 (50:50)
P = 1 atm
A (%)
T (ns)
40.00
0.00
-40.00
-80.00
-120.00
-160.00
-20.00
80.00
180.00
280.00

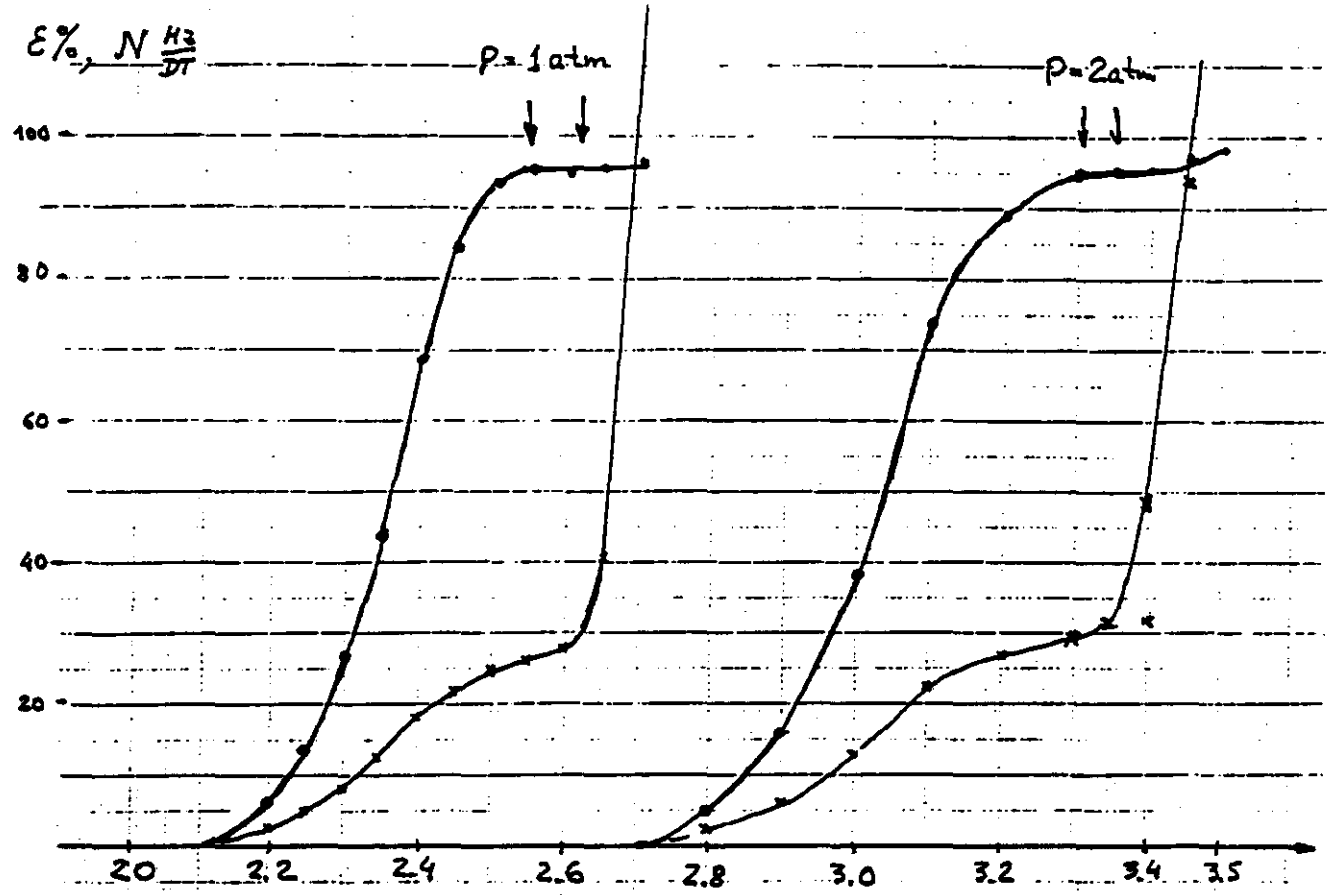

08.02.92
1 LAYER PDT
L=4m,d=3cm
1-ε ≈ 3%
70% ARGON + 30% ISOBUTANE
P=26.5 psi
Eff.%
Noise
100
90
80
70
60
50
40
30
20
10
Cosmic Rays
3.0
3.2
3.4
3.6
3.8
4.0
4.2
4.4
4.6
4.8
5.0
V (k

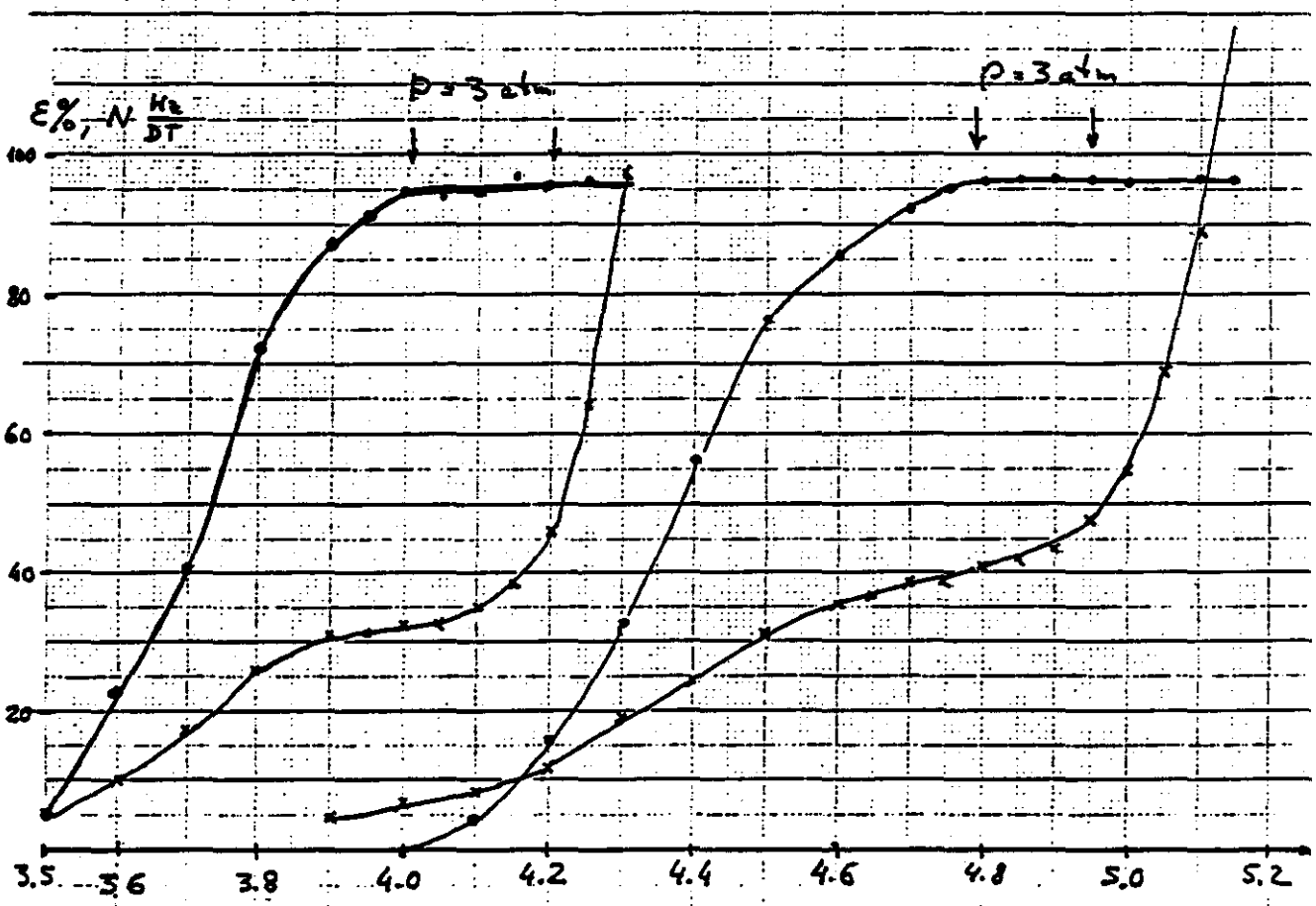

08.03.92
1 LAYER PDT
50% ARGON + 50% ETHANE
Eff.%
L=4m,d=3cm
P=0 psi
Noise Hz/I
100
90
80
70
60
50
40
30
20
10
Cosmic Rays
2.1
2.3
2.5
2.7
2.9
3.1
3.3
3.5
3.7
3.9
V (kV)

08.04.92

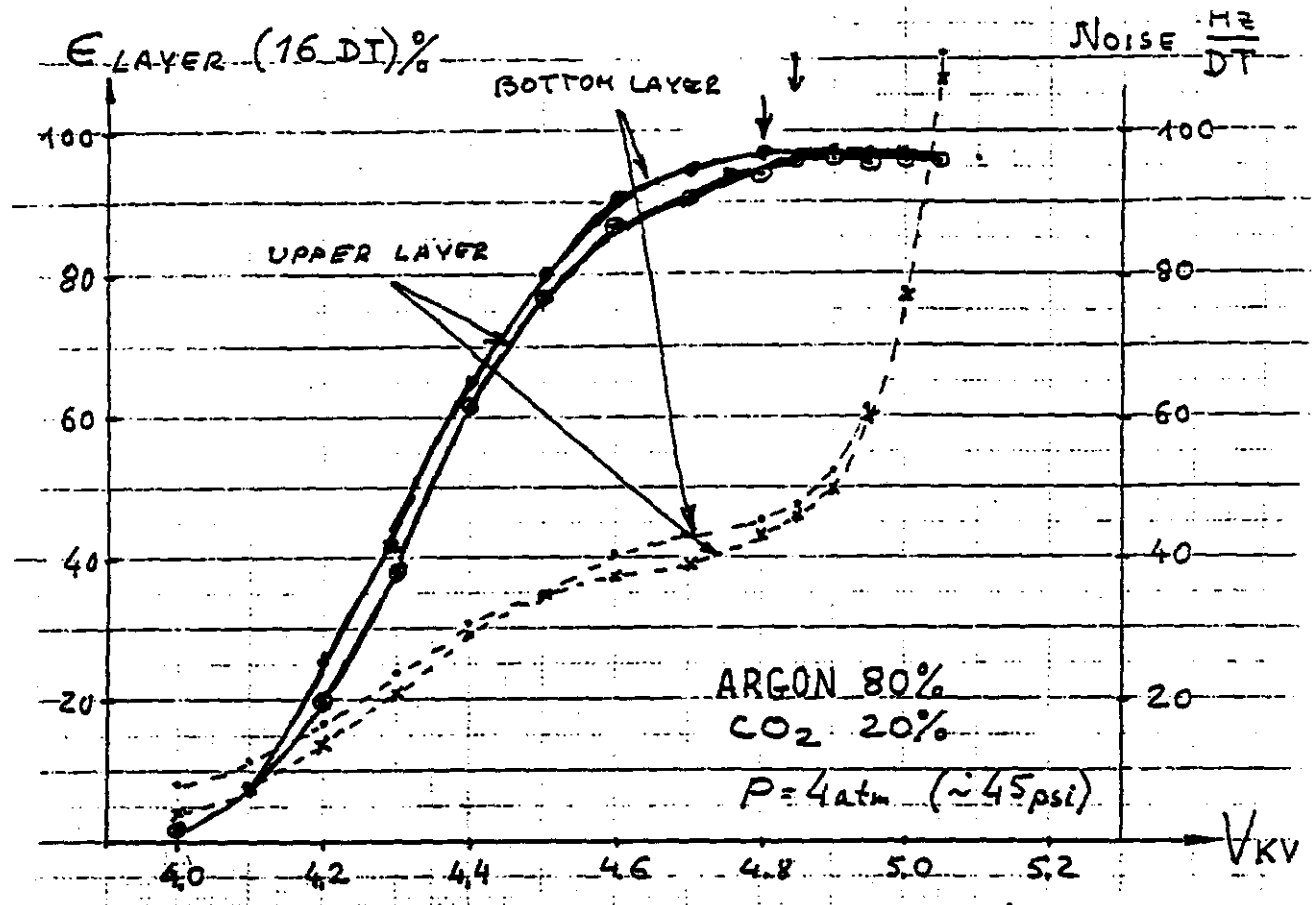

1 LAYER PDT
L=4m,d=3cm
50% ARGON + 50% ETHANE
P= 27.5psi
Eff.%
Noise
100
90
80
70
60
50
40
30
20
10
Cosmic Rays
3.3
3.5
3.7
3.9
4.1
4.3
4.5
4.7
4.9
5.1
5.3
V (kV)

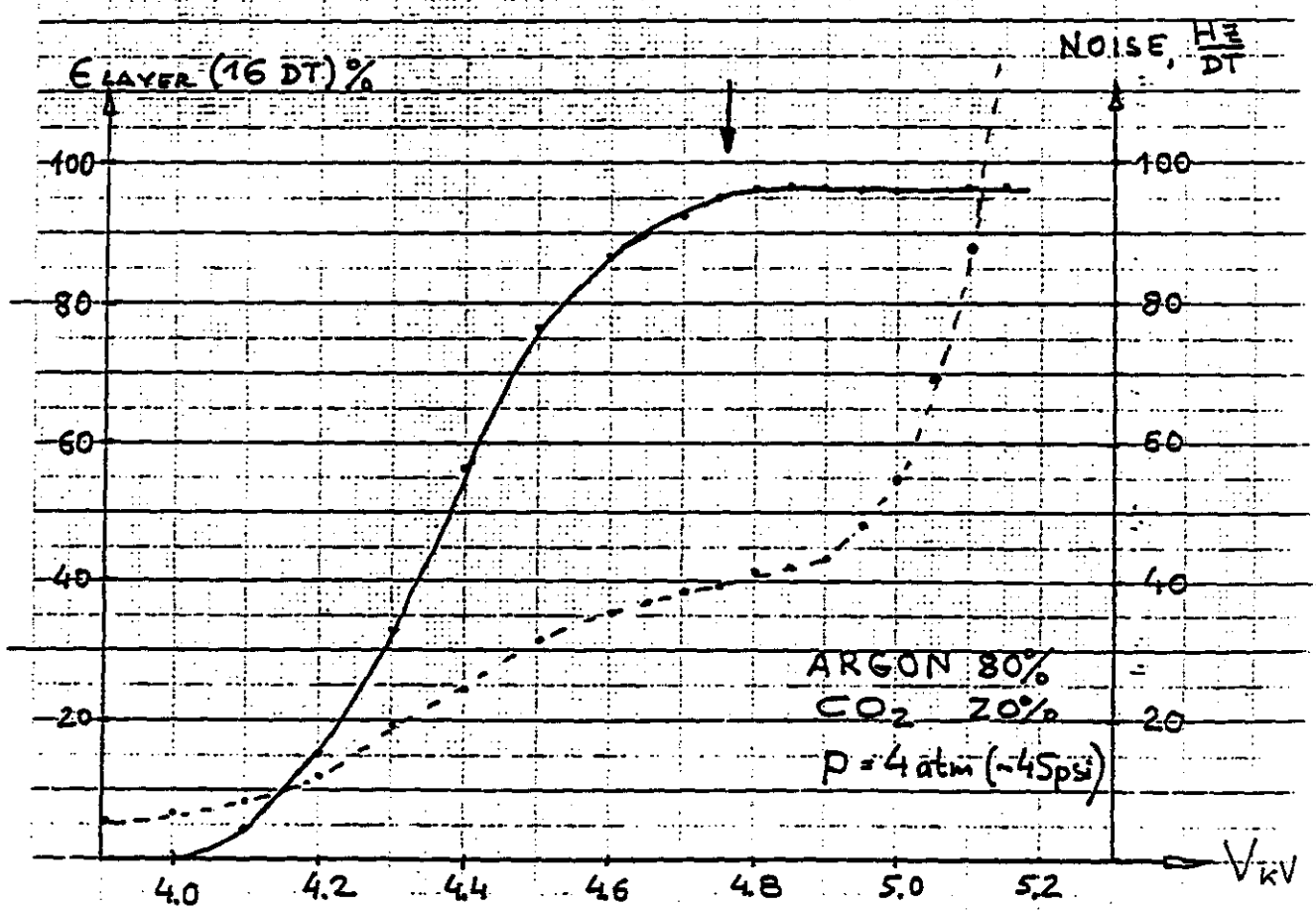

ONE PDT LAYER EFFICIENCY
ε,% Noise, Hz/DT
ARGON 50% + ETHANE 50%
p=0
p=27.5psi
p=42psi
100
90
80
70
60
50
40
30
20
10
2.2
2.4
2.6
2.8
3.0
3.2
3.4
3.6
3.8
4.0
4.2
4.4
4.6
4.8
5.0
5.2
5.4
5.6
5.8
6.0
V kV





ARGON 80% CO_2 20%


ε LAYER (16 DT) %
NOISE Hz/DT
BOTTOM LAYER
UPPER LAYER
100
80
60
40
20
ARGON 80%
CO2 20%
P = 4 atm (~45 psi)
4.0
4.2
4.4
4.6
4.8
5.0
5.2
V KV


ε LAYER (16 DT) %
NOISE, Hz/DT
100
80
60
40
20
ARGON 80%
CO2 20%
P = 4 atm (~45 psi)
4.0
4.2
4.4
4.6
4.8
5.0
5.2
V KV

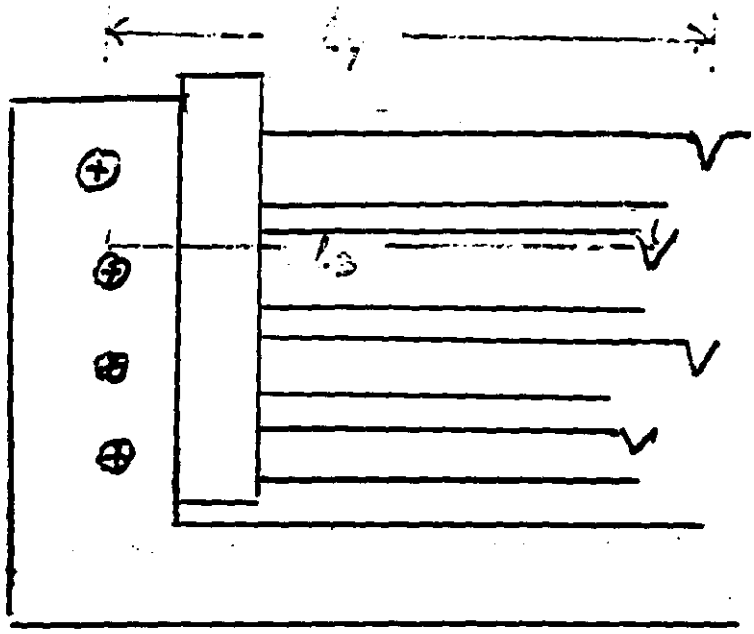
LSDT

L. Osborne

STATUS OF 1 METER X 4 METER CHAMBER

Sept. 2, 1992

Part or Stage		Delivery Date (D=delivered)
Al boxes:machined and welded		7/25,D
Cathode planes (Lincoln Lab.)		7/15,D
Hexcel bottom and top		
	material	D
	preparation	7/20,installed
Bridges		
	blanks	D
	machining	8/3
Posts		7/31,D
Wire(100 μm Au platted wire)		
	material	D
	soldering(courtesy of LLNL)	D
Electronics:		
	HV cards	7/20,D
	delay lines	7/20,D
	discriminator cards	8/7,D
Assembly:	Start	8/20
	Finish	9/9
Test:	Start	9/10
	Finish	9/19
Delivery to SSCLab		9/21



$l_3 + (l_4 - 12.63)$ for 3 layers, 3 bridges

254.619

.629

.619

.627

.647

.607

.631

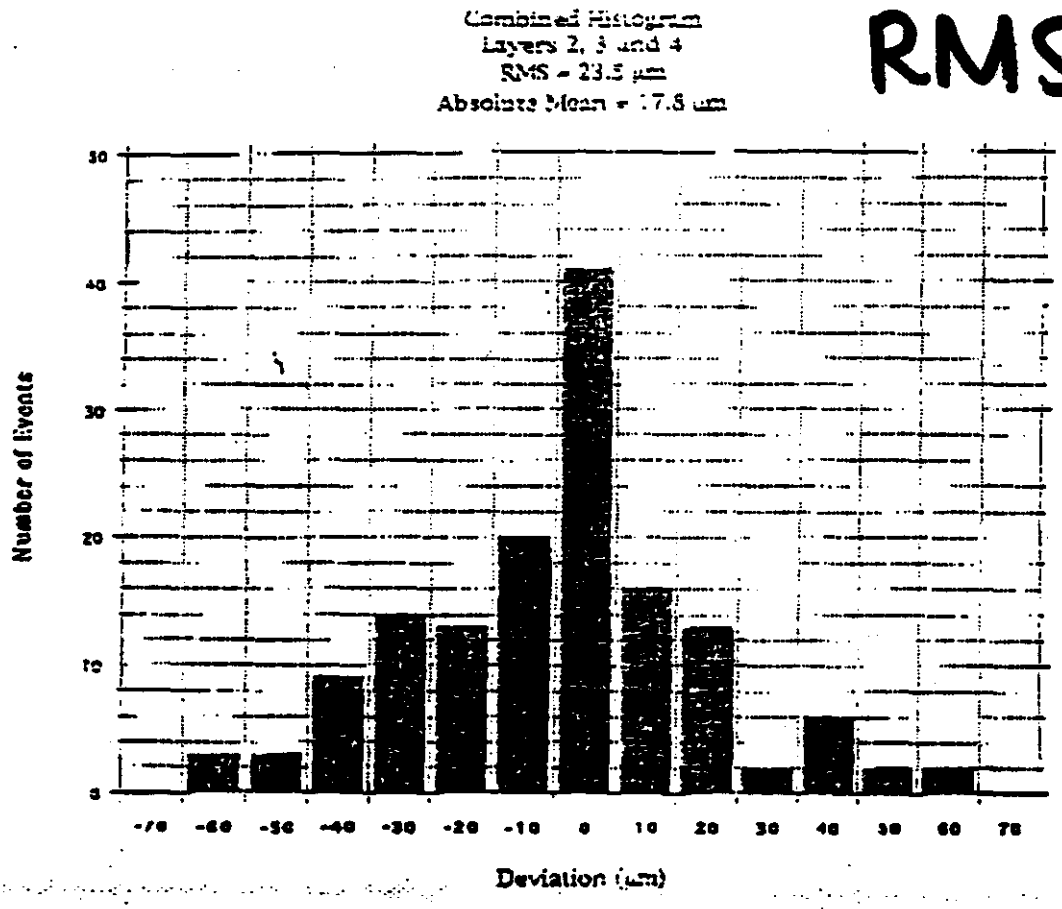
.621

.625

WITHIN ±20μm

WIRE MISALIGNMENT WITH RESPECT TO EXTERNAL REFERENCE POINT

RMS≈24 μm



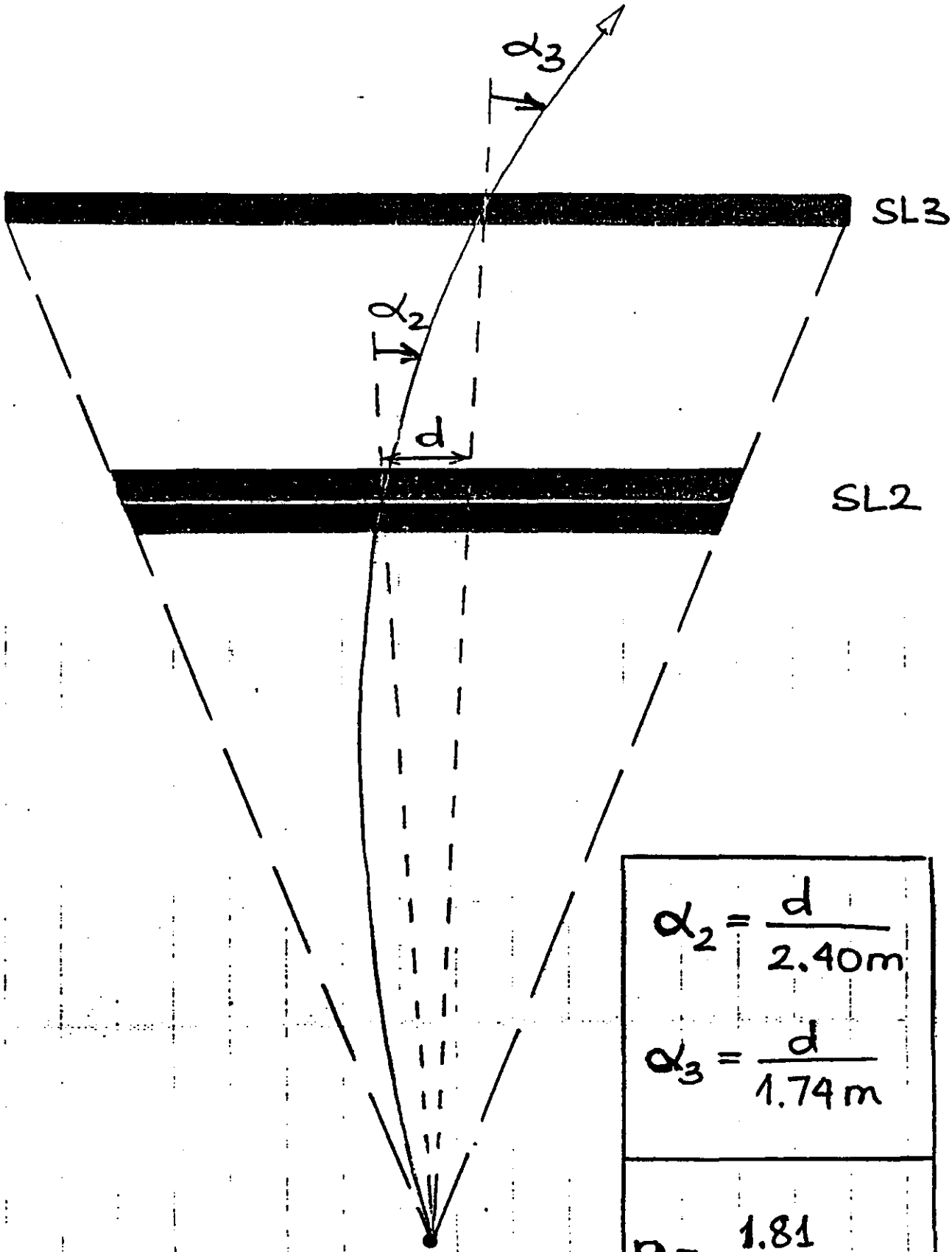
LSDT Trigger

A. Korytov

September 2, 1992

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

MOMENTUM and TIME TRIGGER based on LSDT's



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

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

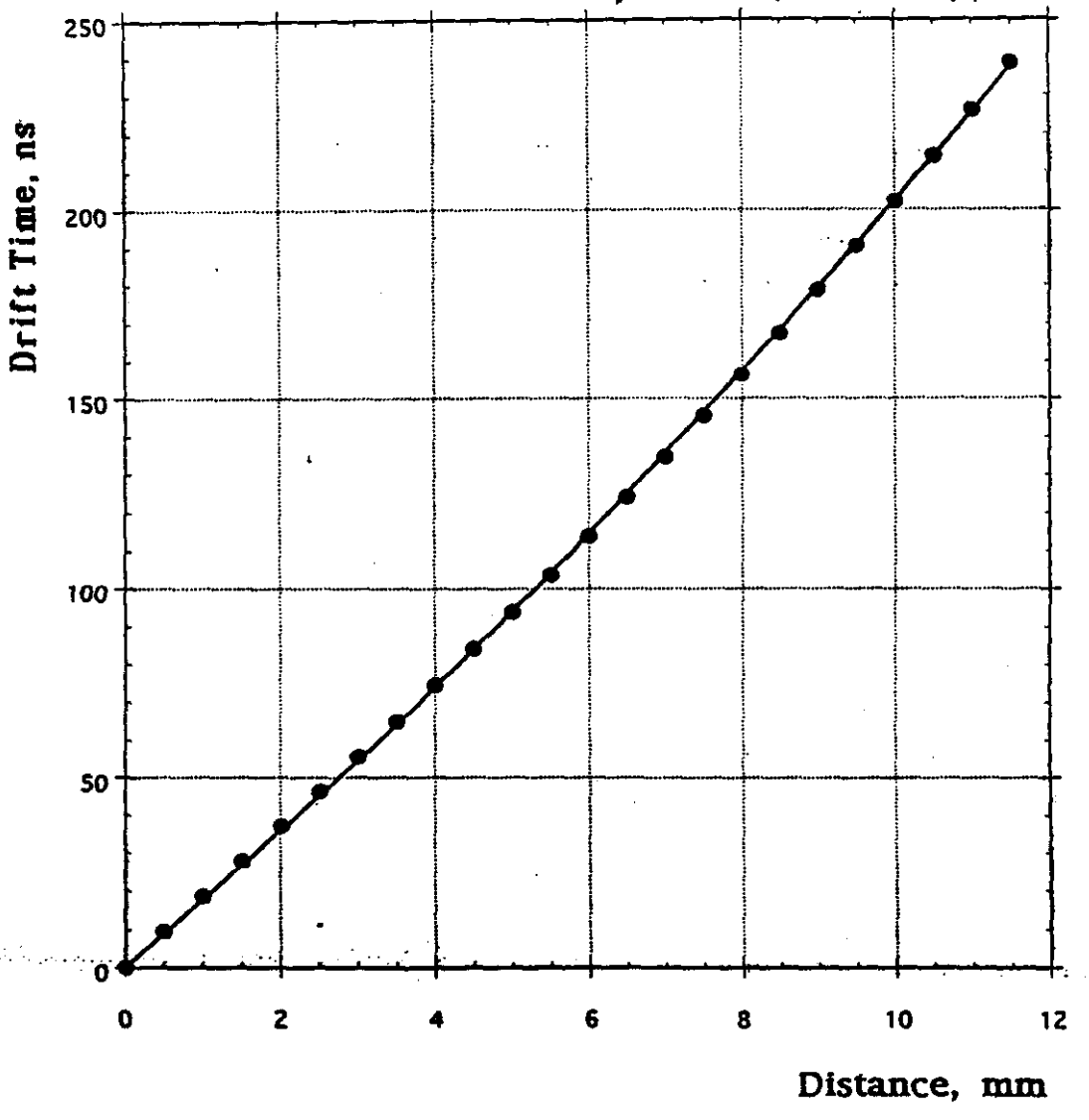
$$p = \frac{1.81}{d\,(m)}$$

$\alpha_2 = 4.4°$ for $p = 10$ GeV/c

y = m1*M0 + m2*M0*M0		
	Value	Error
m1	17.357073062	0.094725
m2	0.28546071821	0.0104131
Chisq	13.306709133	NA
R	0.99994534341	NA

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

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



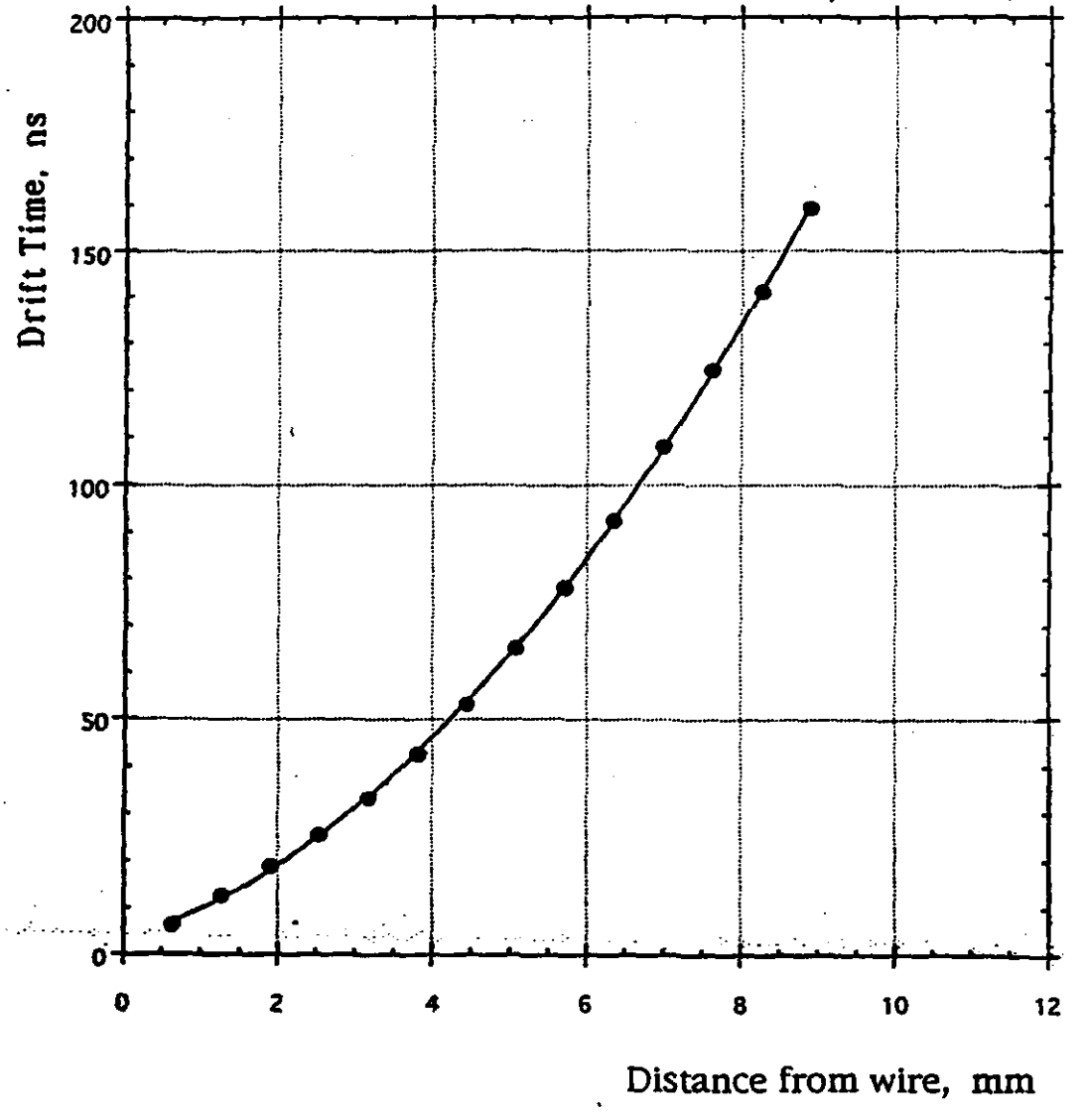
y = m1+m2*M0 + m3*M0*M0		
	Value	Error
m1	3.3417585497	0.484641
m2	5.031063318	0.23408
m3	1.4116950994	0.0239047
Chisq	2.9760939244	NA
R	0.99995388072	NA

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

U = 5.4 kV

Laser Data

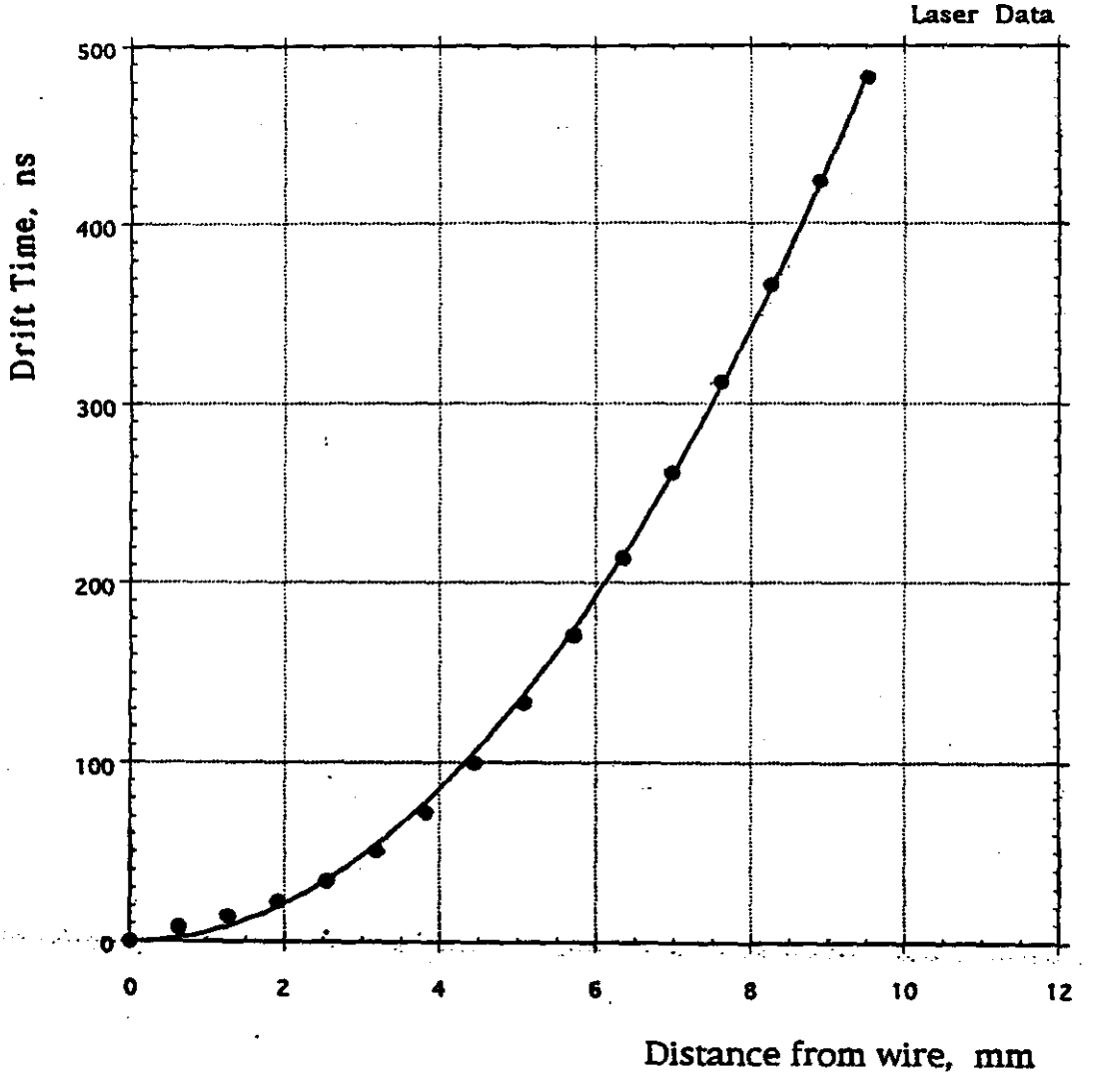
$T = a \cdot x + b \cdot x^2$

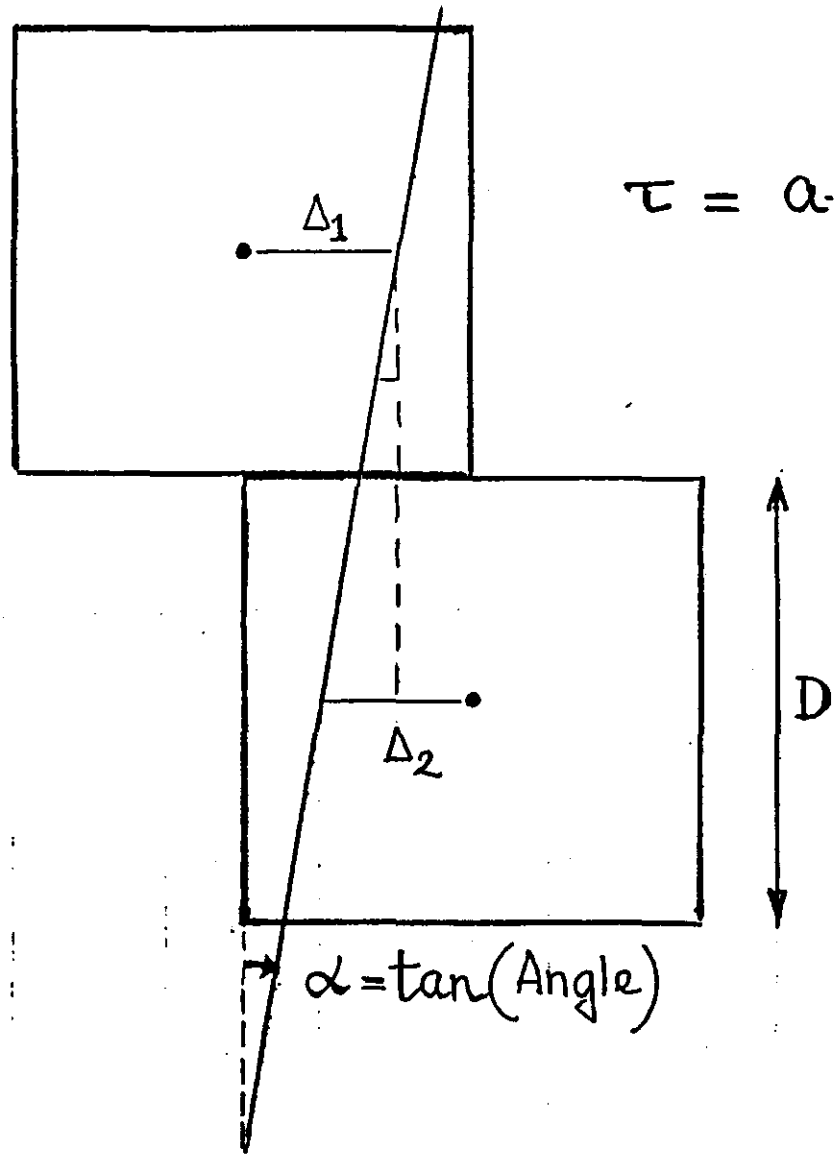


T=b*x^2		
	Value	Error
b	5.3277617937	0.0214464
Chisq	199.89911477	NA
R	0.99973685403	NA

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

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

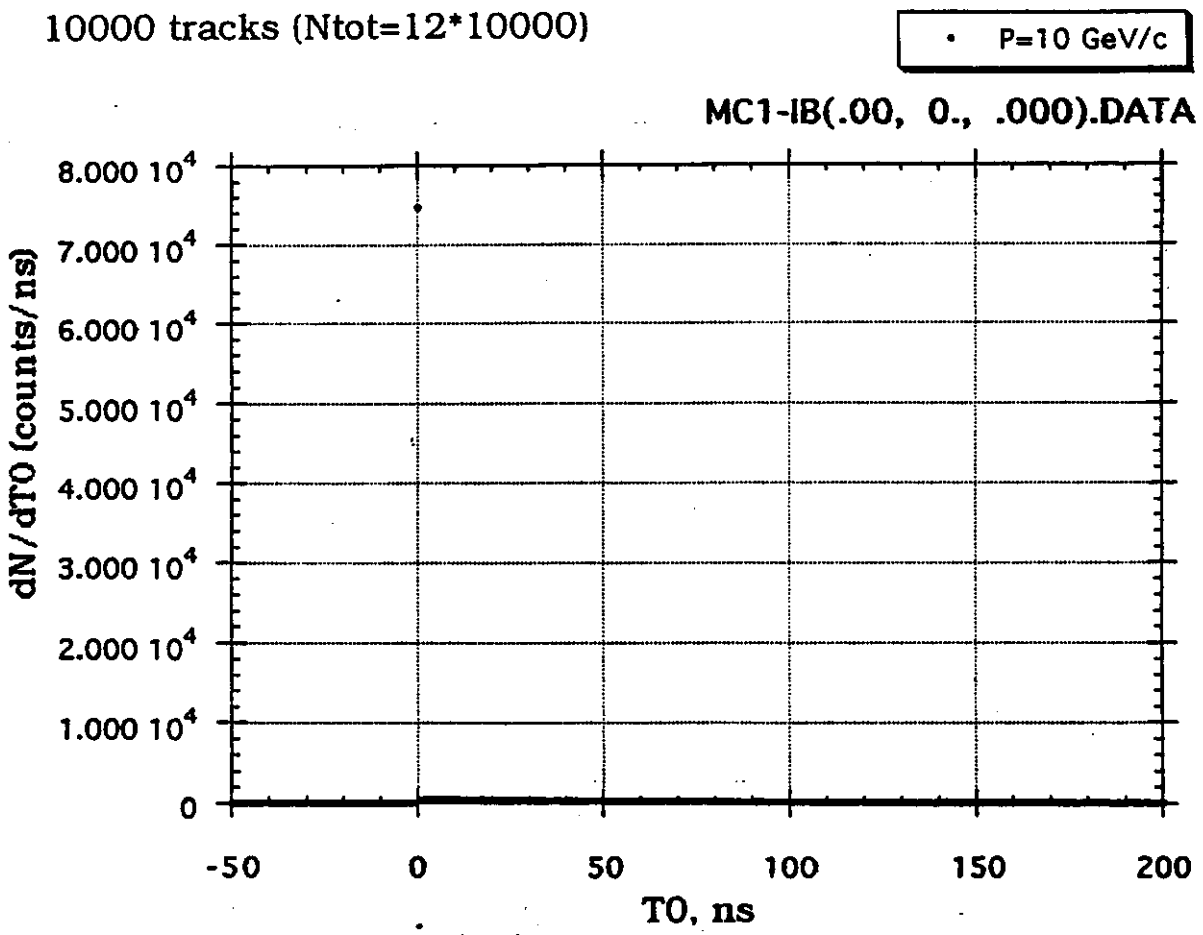




$$\tau = a \cdot \Delta + b \cdot \Delta^2$$

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

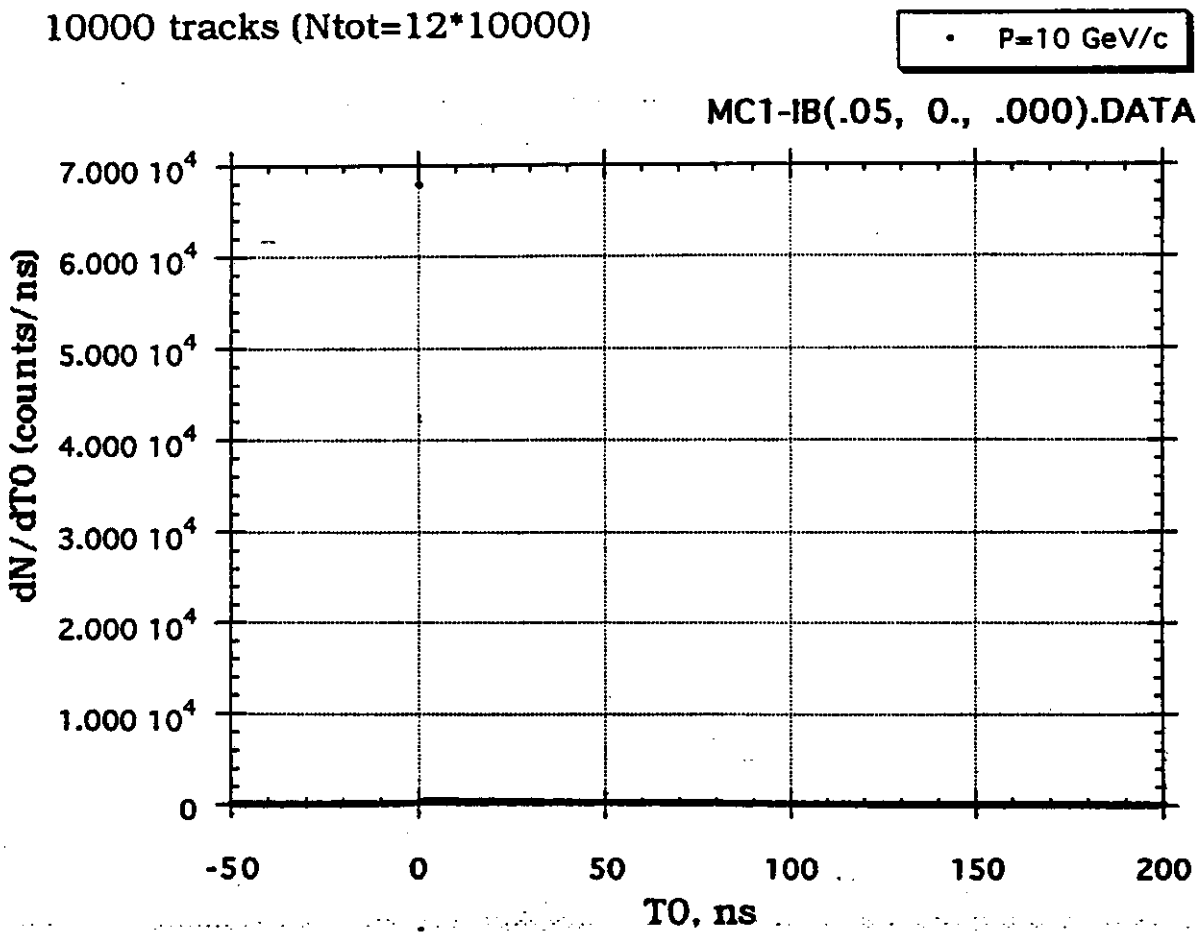
$$C_0 = \frac{D}{2} + \alpha \cdot D$$


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

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

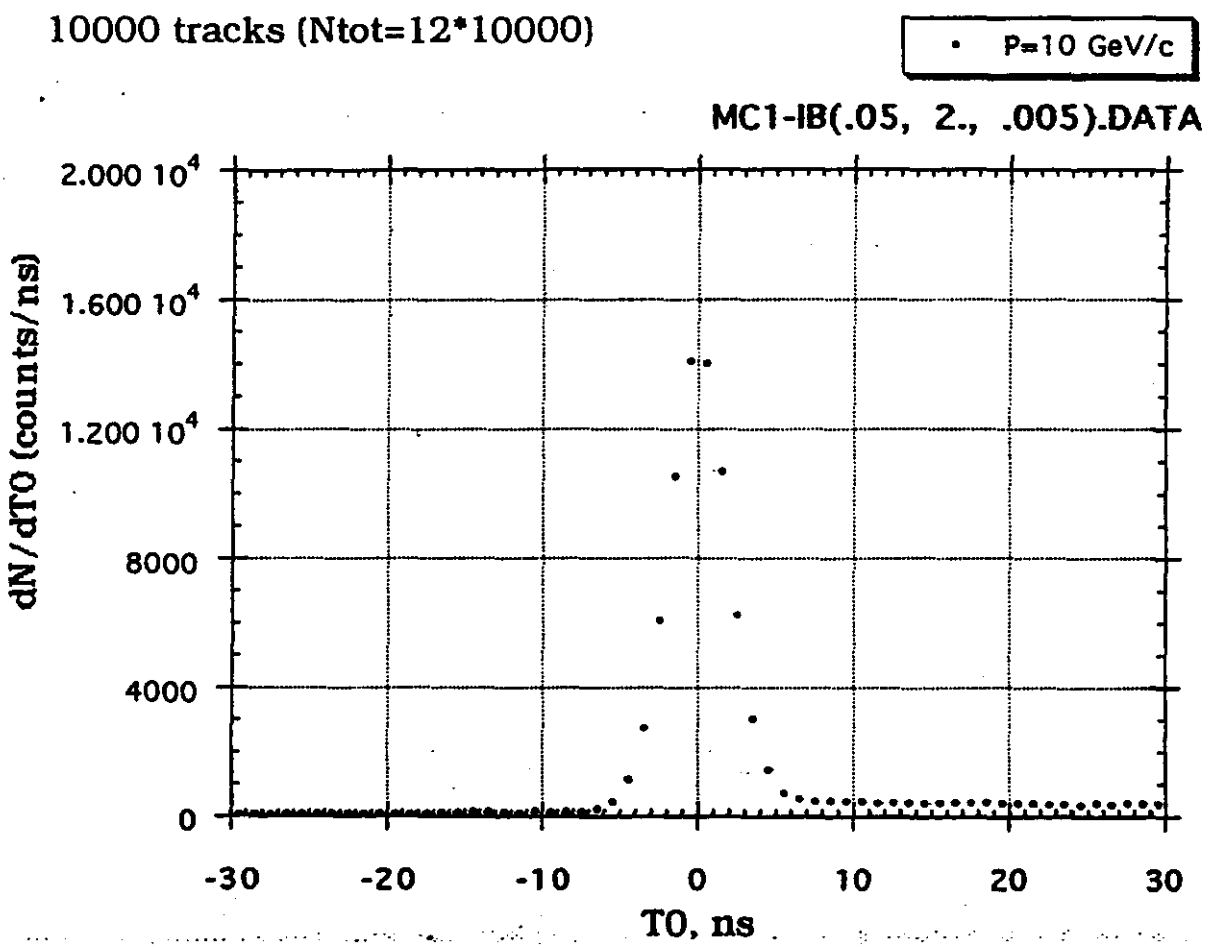
Coincidence Level	p=10	=20	=40	=80	=160	=320
0	0	0	0	0	0	0
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4	0	0	0	0	0	0
5	0	0	0	0	0	0
6	796	1003	1162	1199	1239	1245
7	2293	2593	2639	2642	2656	2716
8	5104	4673	4596	4510	4449	4417
9	1640	1565	1426	1468	1444	1447
10	165	162	171	176	208	166
11	2	2	5	5	4	7
12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

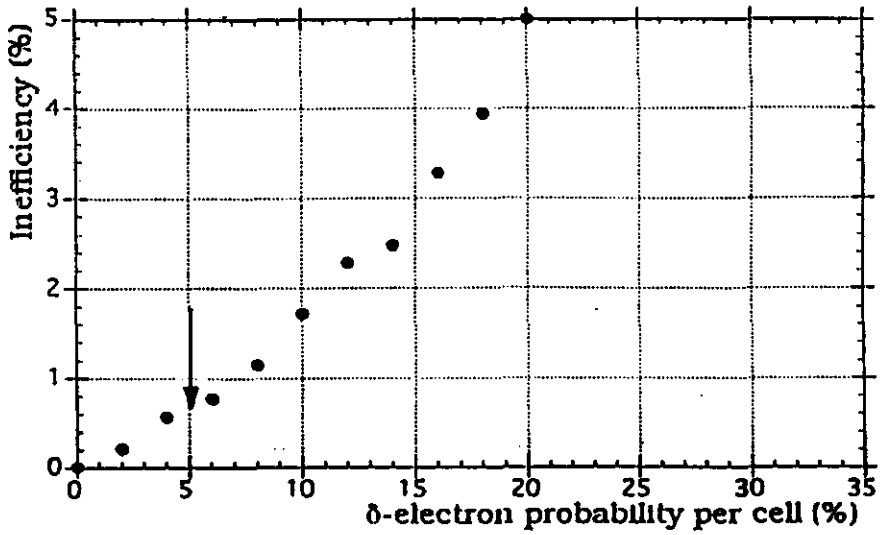
$\delta T = 2$ ns

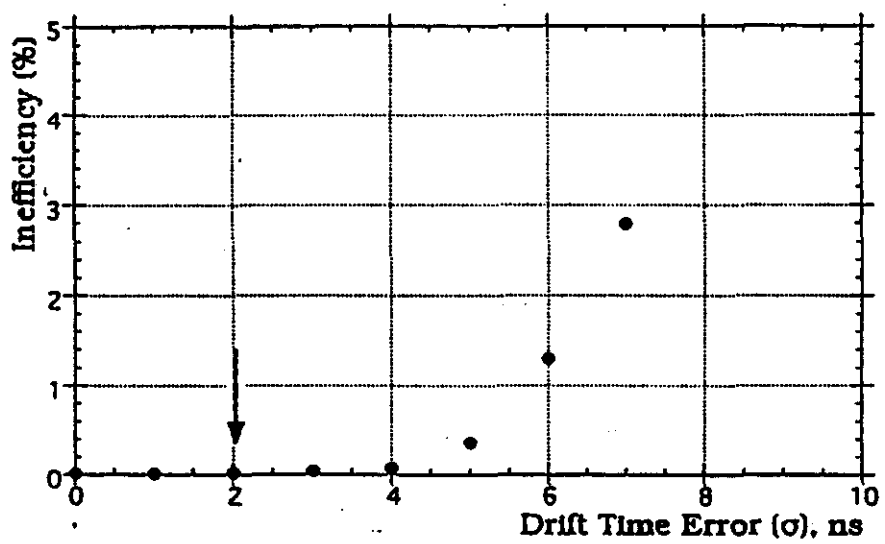
$\delta\alpha = .005$ ($\approx .3°$)

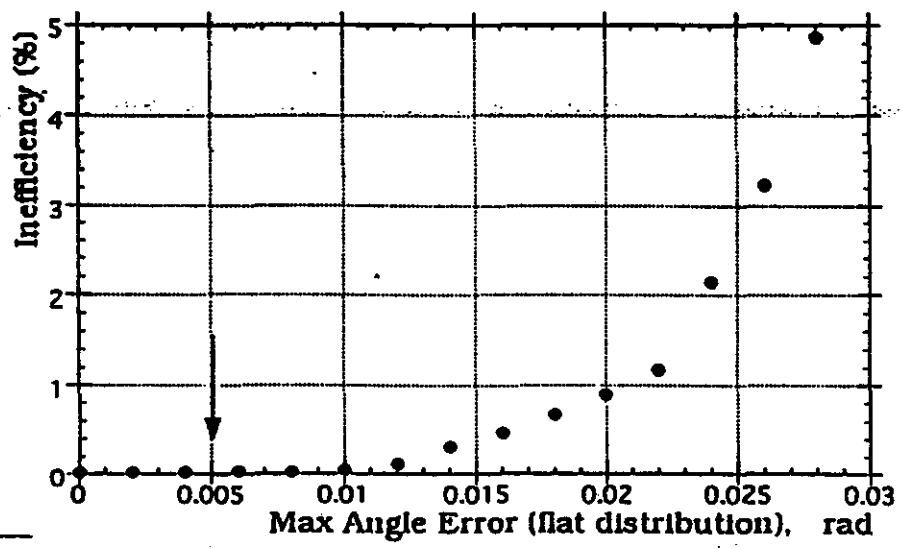


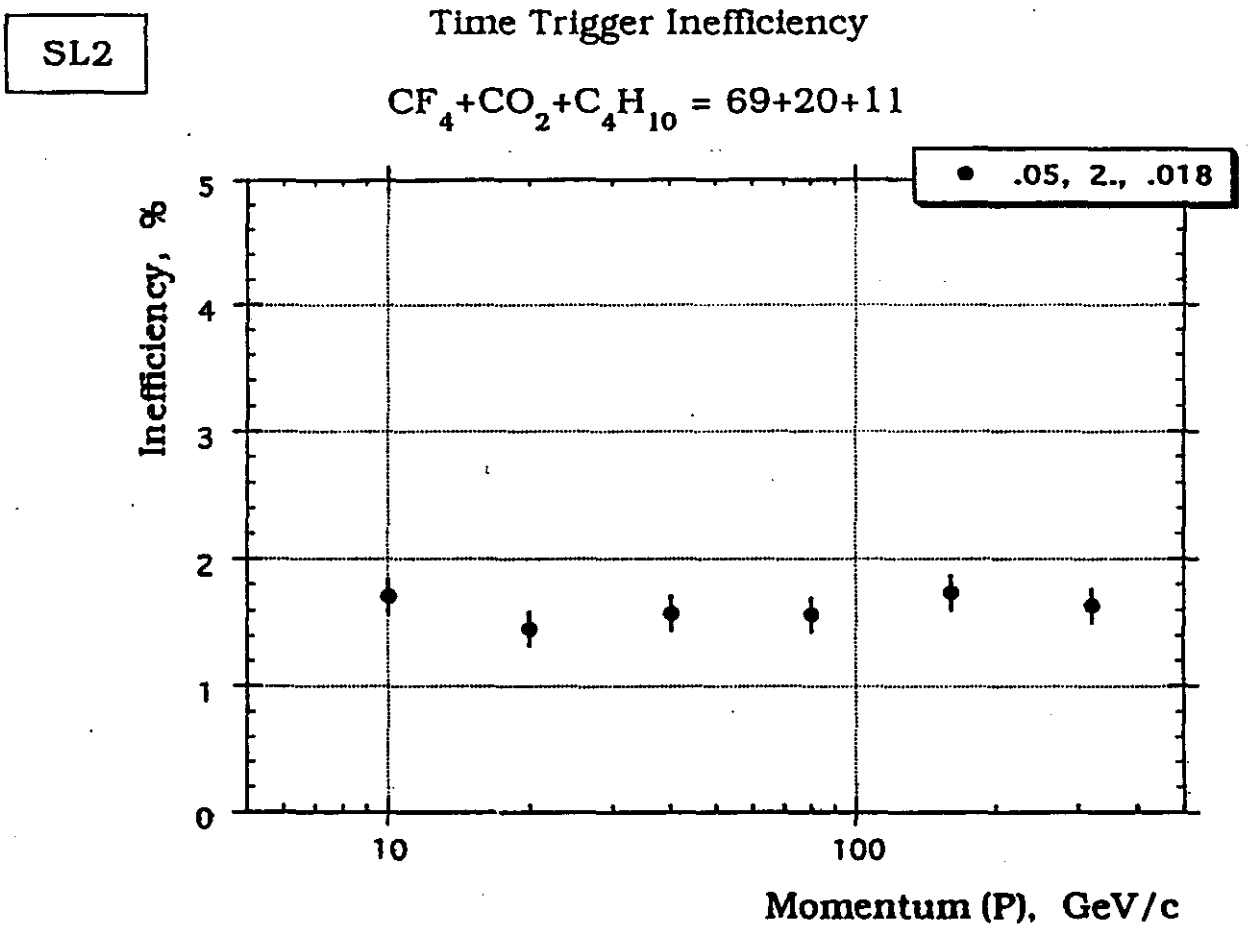
SL2

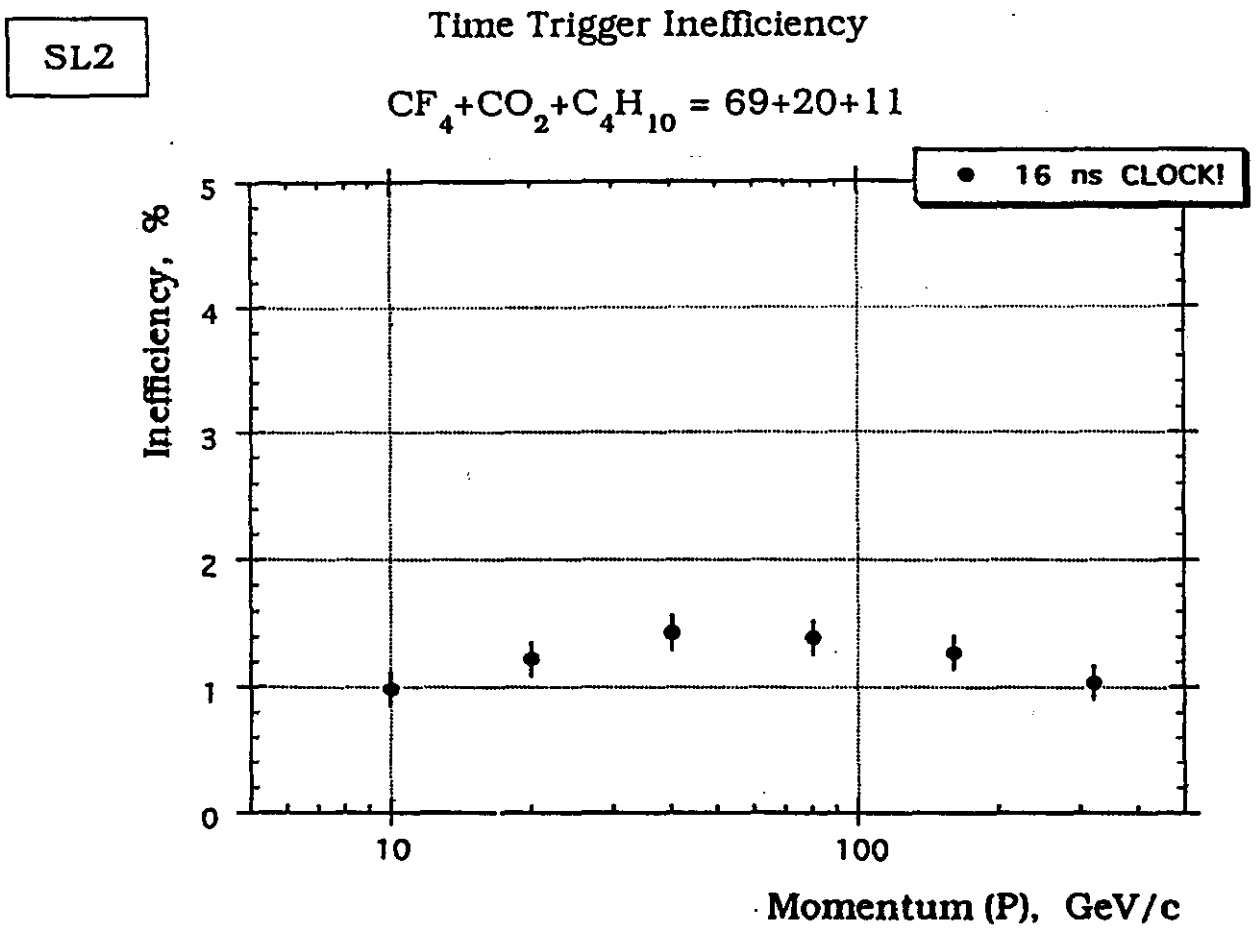
$CF_4+CO_2+C_4H_{10}$ = 69+20+11



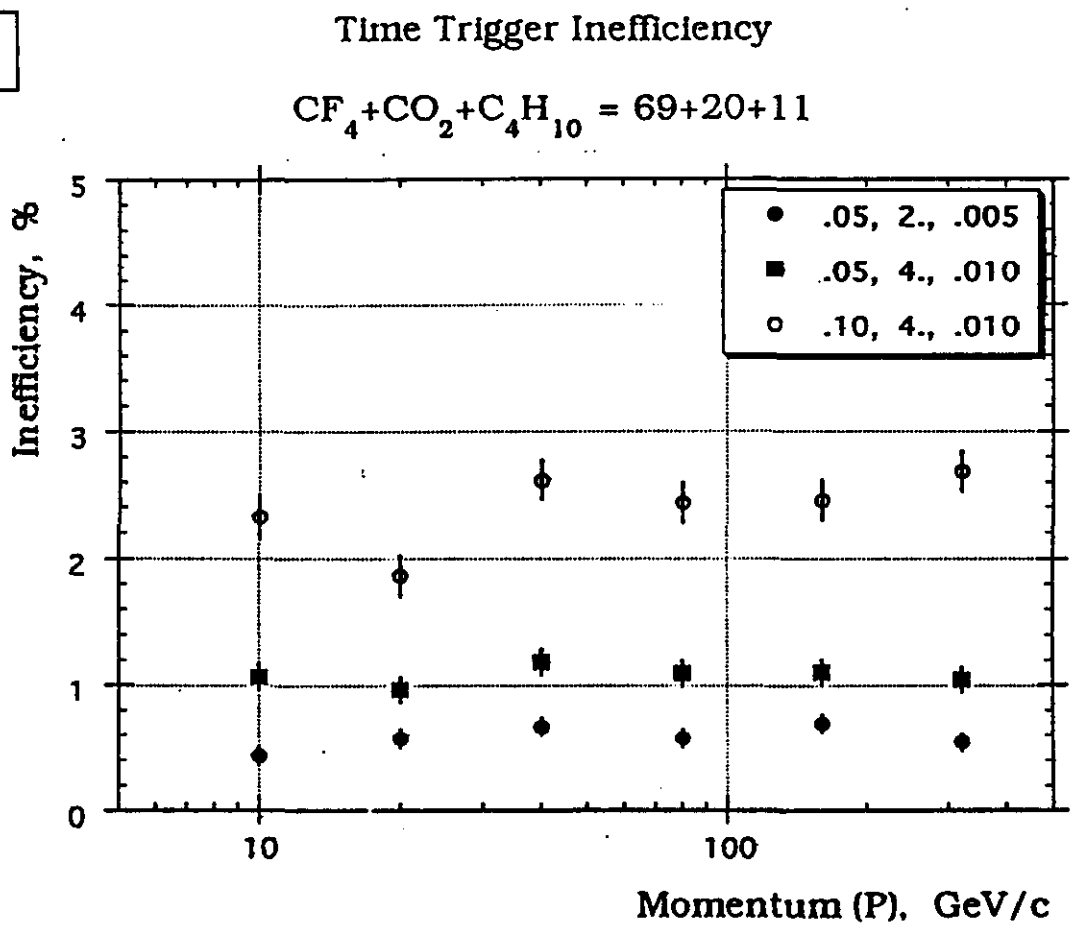




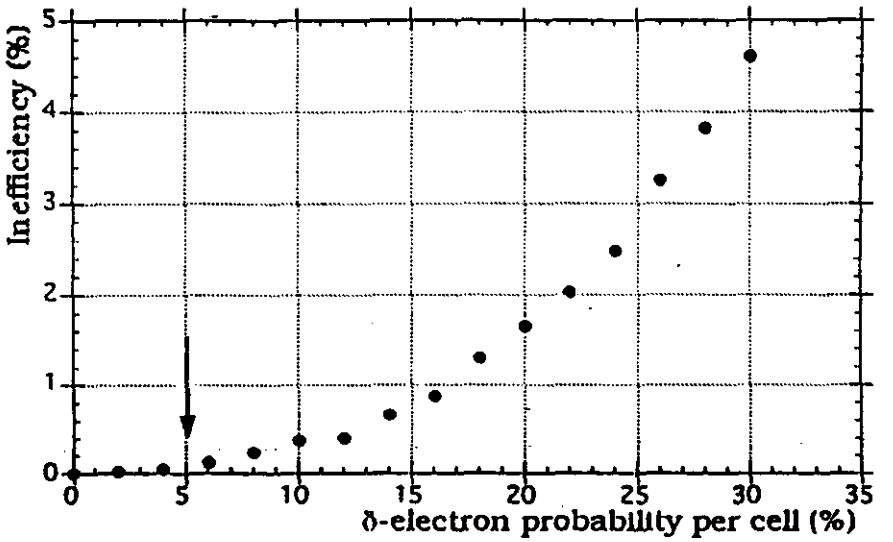

SL2
Time Trigger Inefficiency
$CF_4+CO_2+C_4H_{10}$ = 69+20+11
.05, 2., .018
Inefficiency, %
5
4
3
2
1
0
10
100
Momentum (P), GeV/c

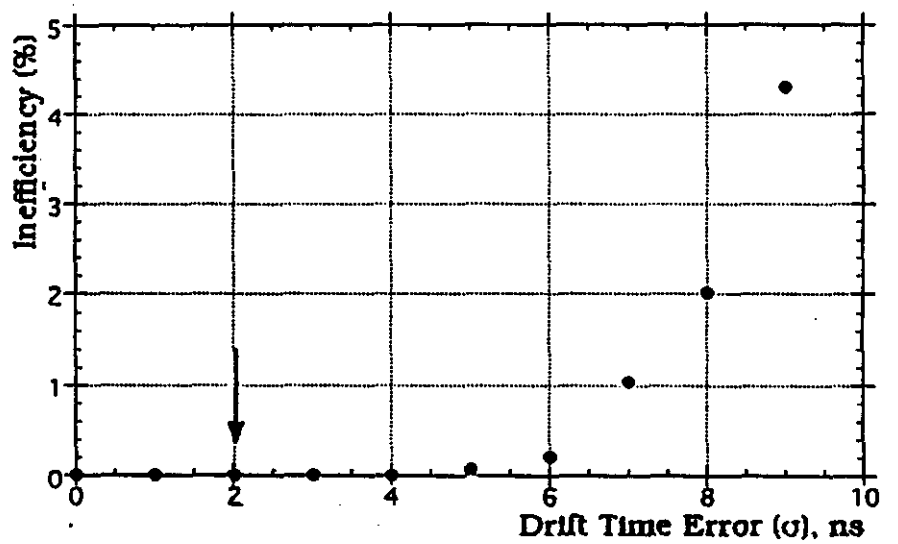

SL2
Time Trigger Inefficiency
$CF_4+CO_2+C_4H_{10}$ = 69+20+11
16 ns CLOCK!
Inefficiency, %
0
1
2
3
4
5
10
100
Momentum (P), GeV/c

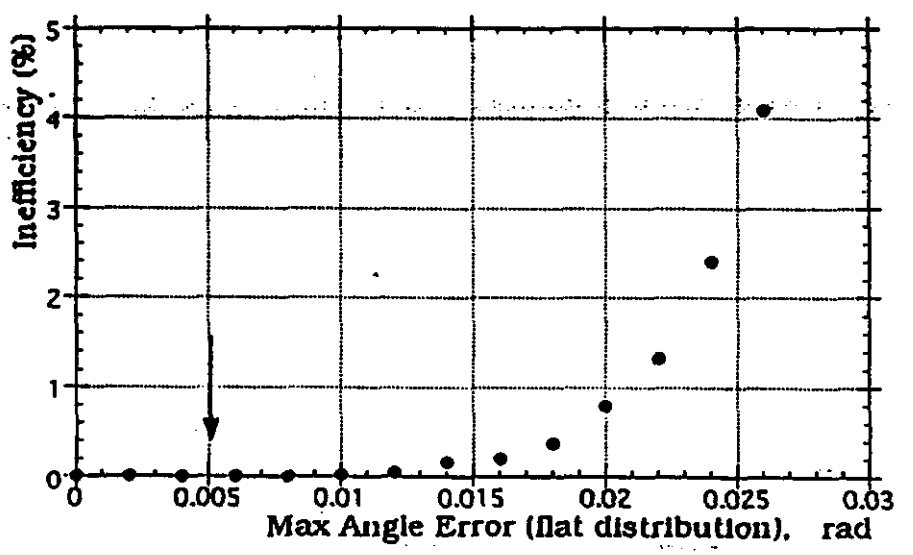
SL2

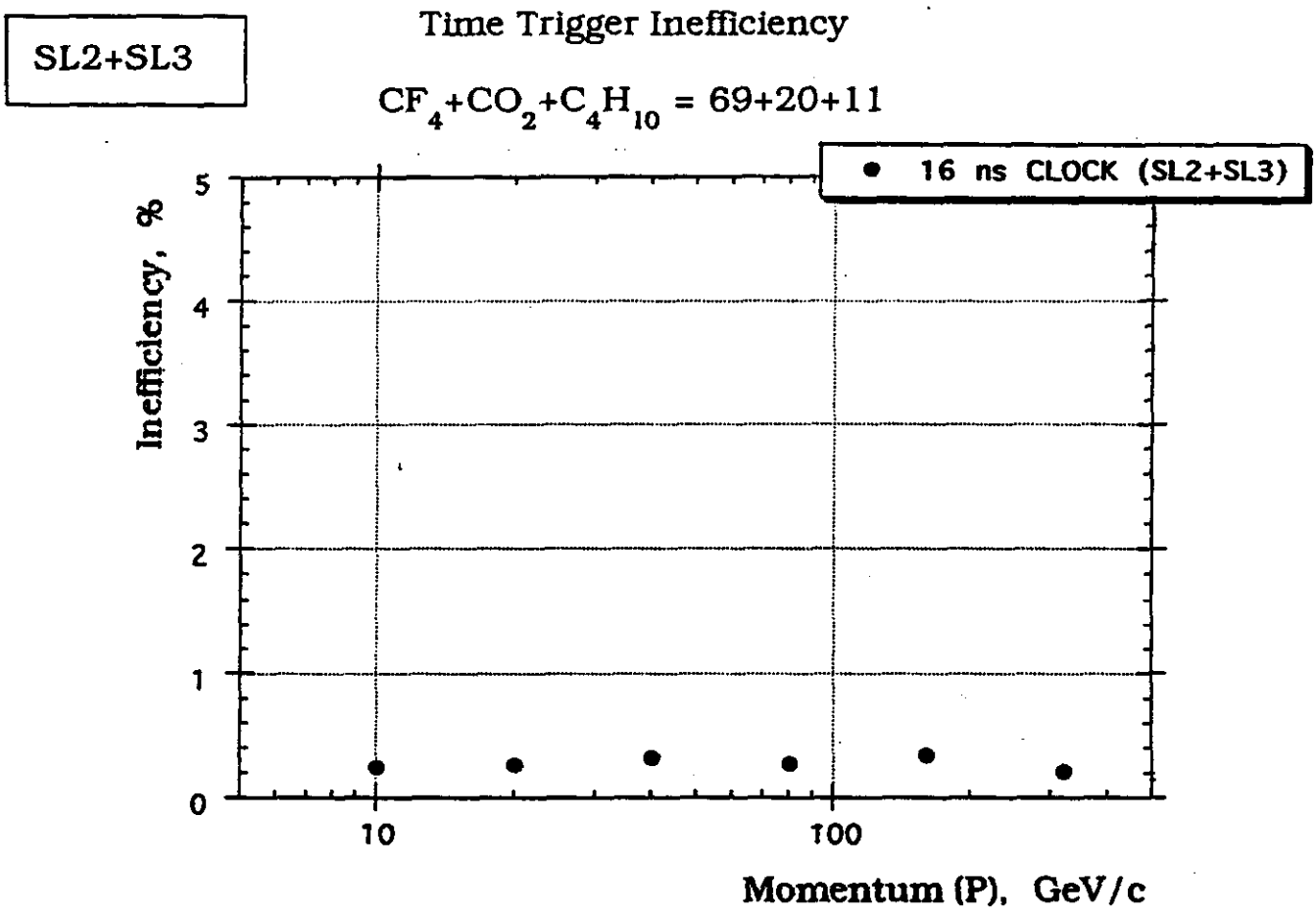

Time Trigger Inefficiency
$CF_4+CO_2+C_4H_{10}$ = 69+20+11
Inefficiency, %
Momentum (P), GeV/c
.05, 2., .005
.05, 4., .010
.10, 4., .010
0
1
2
3
4
5
10
100

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







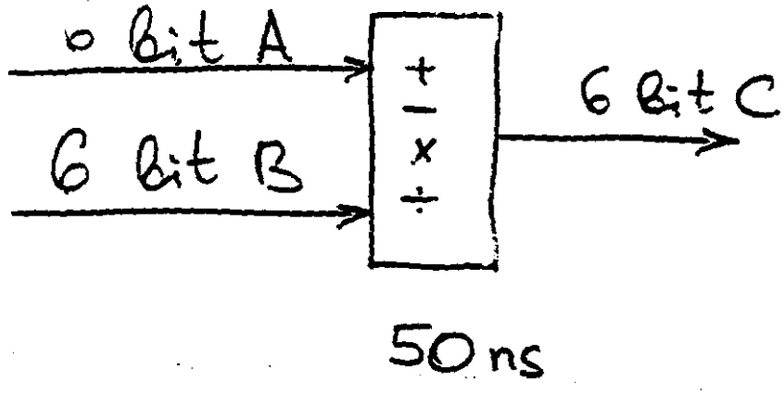

SL2+SL3
Time Trigger Inefficiency
$CF_4+CO_2+C_4H_{10}$ = 69+20+11
16 ns CLOCK (SL2+SL3)
Inefficiency, %
5
4
3
2
1
0
10
100
Momentum (P), GeV/c

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

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 (αC_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 $\left(\frac{b}{4}\right)$	Z1 = Y1/Z1 $\left(\Delta T^2/(a+bC_0)^2\right)$
# 7	—	—	Z1 = Z1 * Y2 $\frac{b}{4}\left(\Delta T^2/(a+bC_0)^2\right)$
# 8	X1 = X1 − Z1 (T_0)	—	—



* Drift time Range 300ns/16ns≈20 (5 bits)
* Angle Range ± 16°/1° = ±16 (6 bits)
  (this corresponds to δα = .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

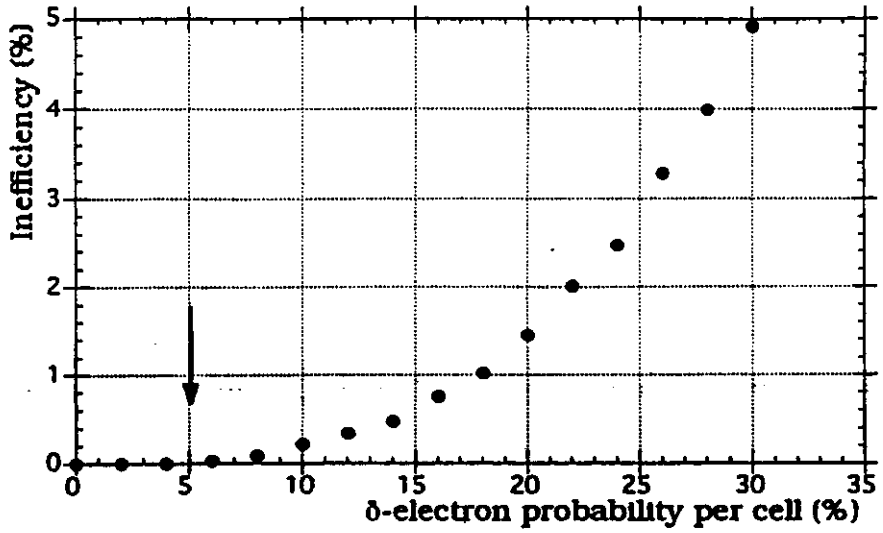
Time Budget (p_T)

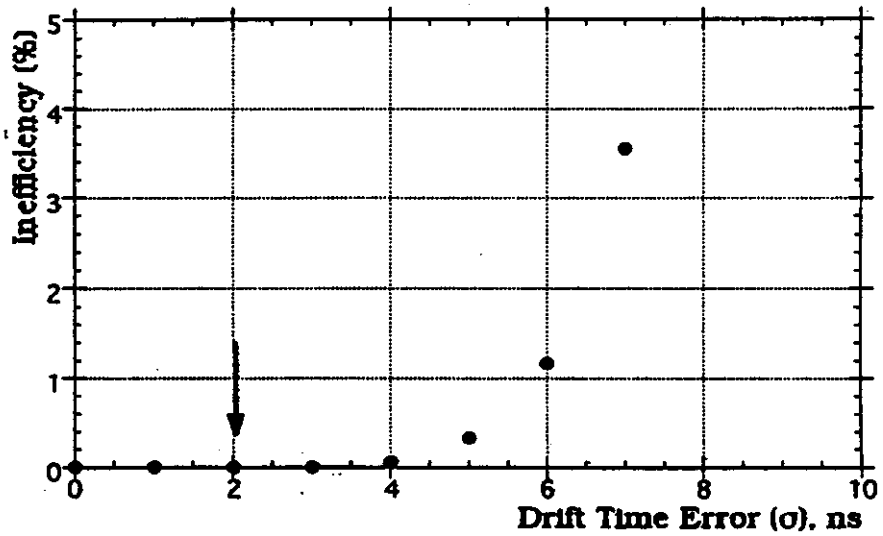
Drift Time	$\leq$ 300 ns
p_T (3 steps)	150 ns
	450 ns

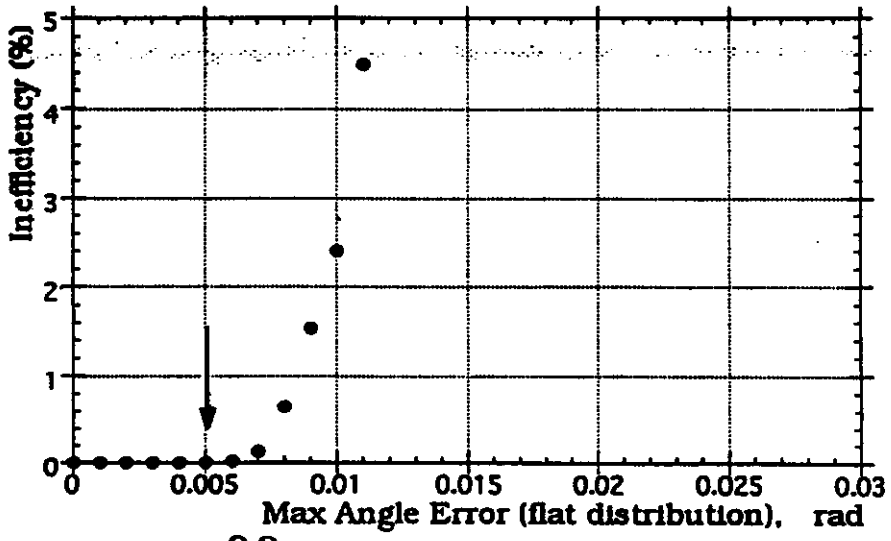
a= 9.9999998E-03 D= 5.327762
KEY=1
eps=.000 Terror(ns)=0.0 Aerror(rad)=.000

= 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 (%)
δ-electron probability per cell (%)


Inefficiency (%)
Drift Time Error (σ), ns


Inefficiency (%)
Max Angle Error (flat distribution), rad

L-Angle Studies

O. Prokofiev

Electron drift and magnetic deflection angle measurements in fast CF_4 based gas mixtures for GEM muon chambers

O. Prokofiev PNPI

Experimental set-up:

Proportional chamber with drift gap

Drift gap 9.45 mm

A new method measurements W and α with α-decay recoil

Accuracy $\Delta W/W = 1\%$ $\Delta\alpha = 0.5°$

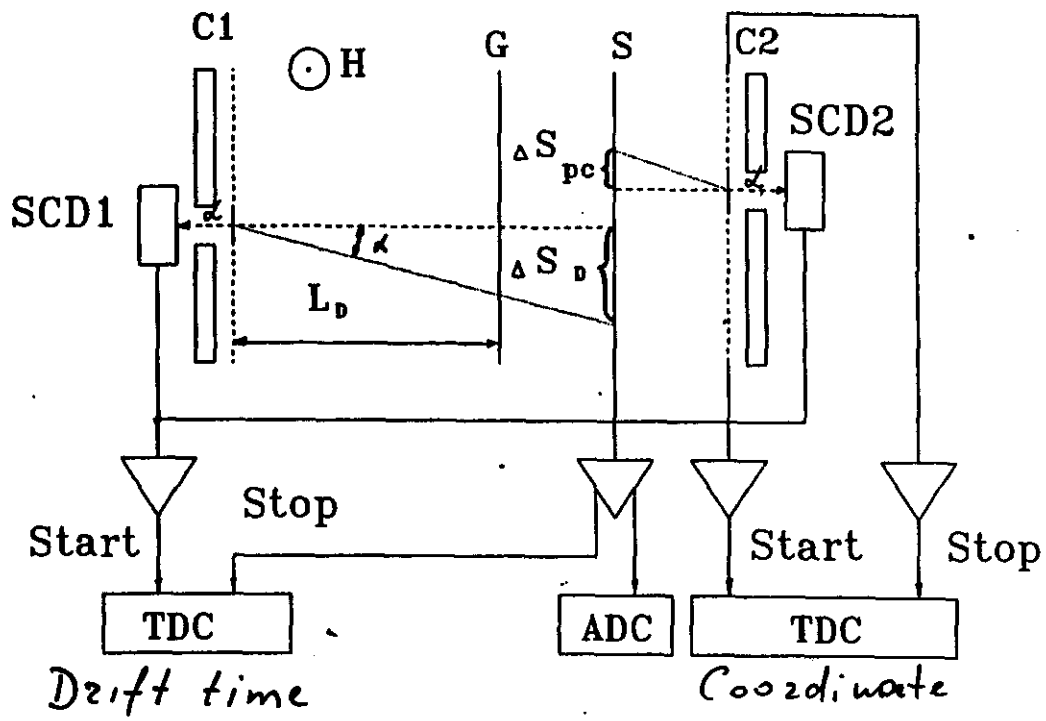
α-source ^{208}Po 1.5 α/sec

Range of measurements:

Electric field up to 10 kV/cm

Magnetic field up to 1.5 T

Experimental set-up



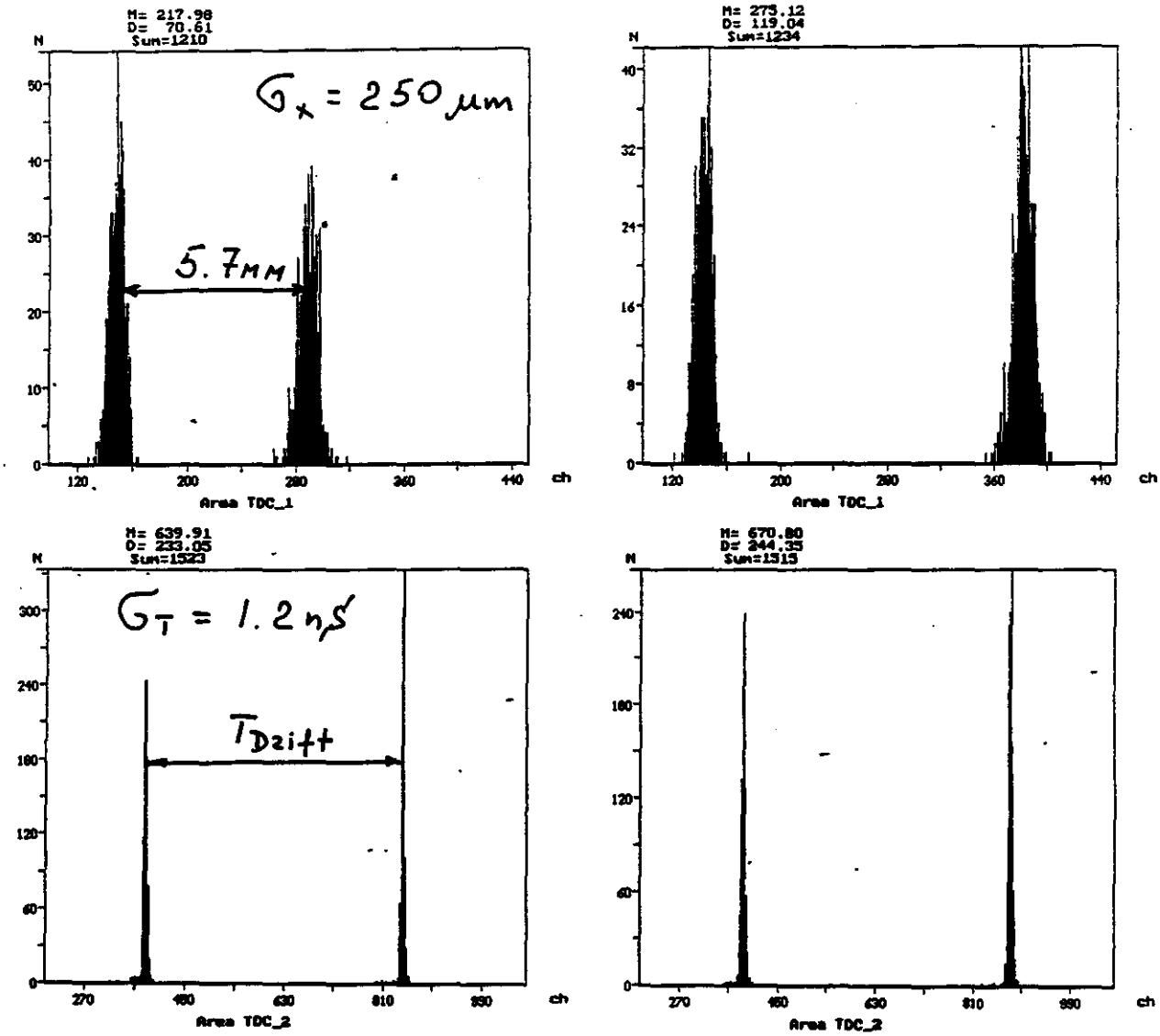
^{208}Po - α source

$$tg\,\alpha = \frac{\Delta S_D - \Delta S_{pc}}{L_D}$$

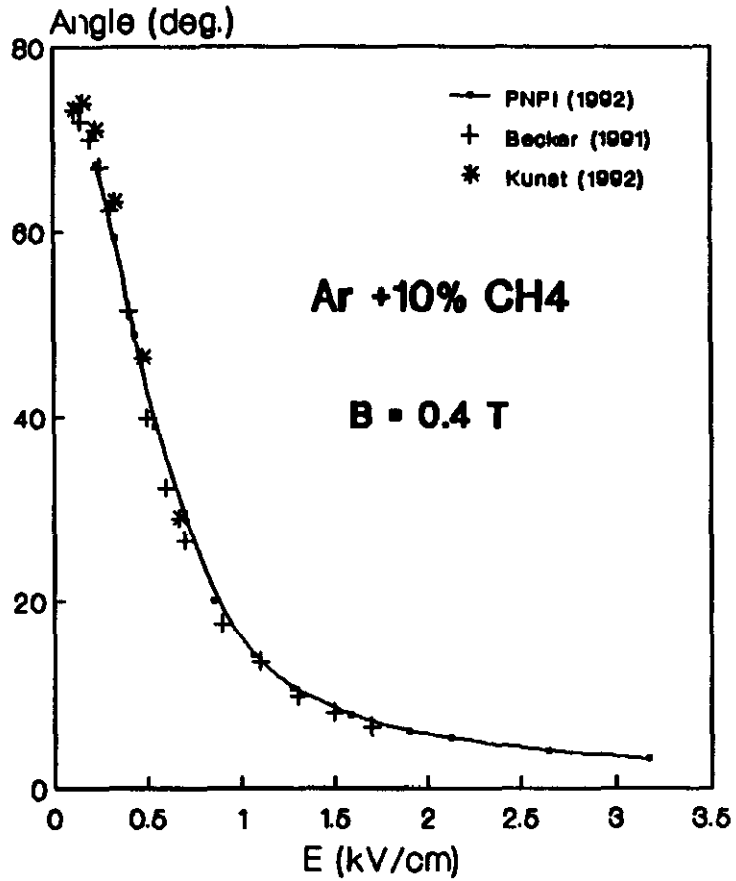
$Ar + 50\% \; C_2H_6$

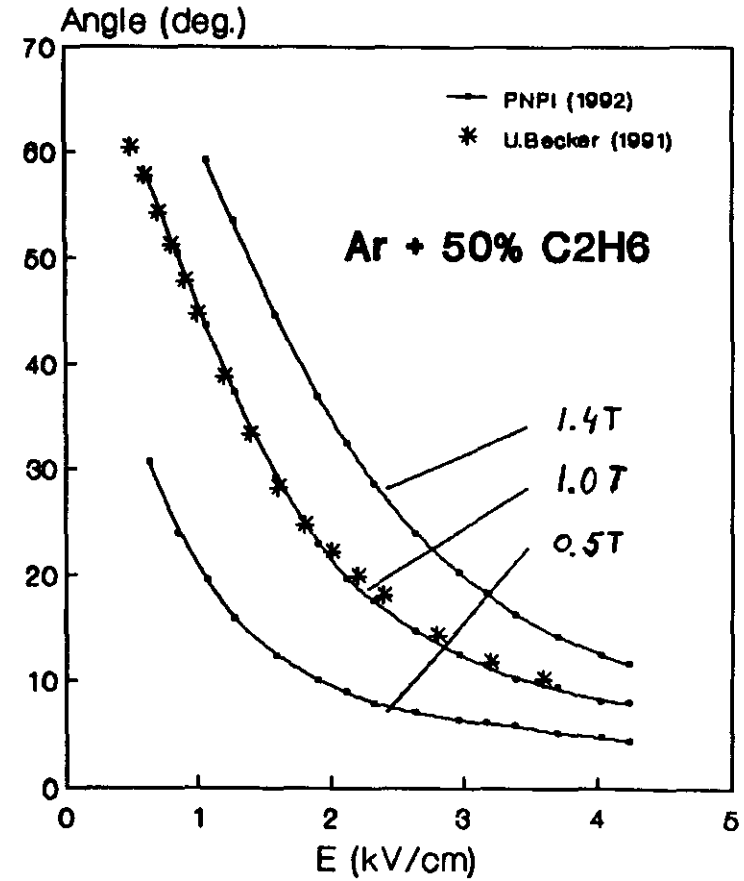
$E_D = 1.06 \, kV$

$B = 0$ $\qquad$ $B = 0.5T$

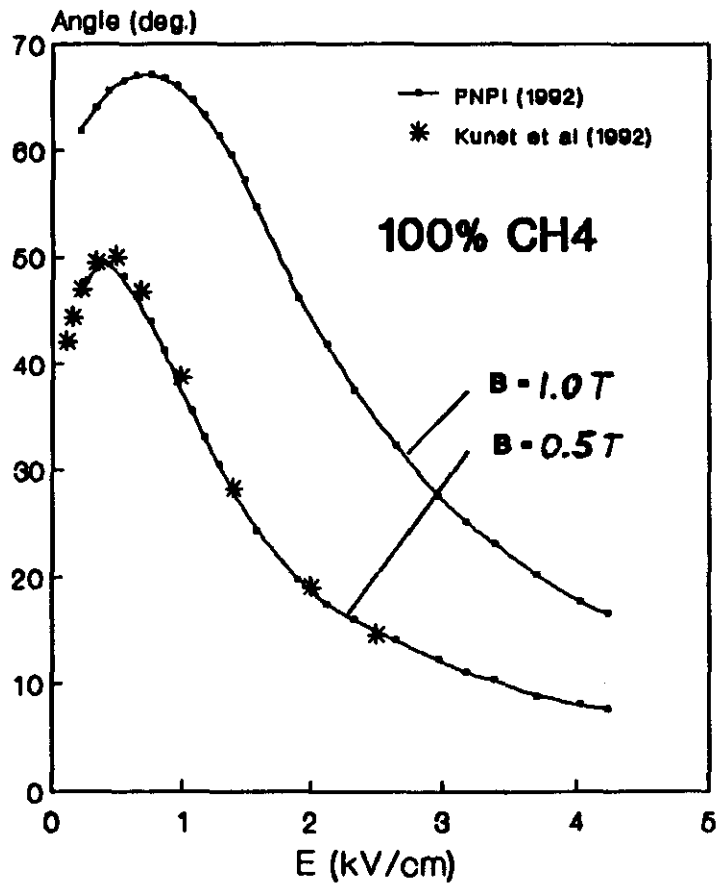


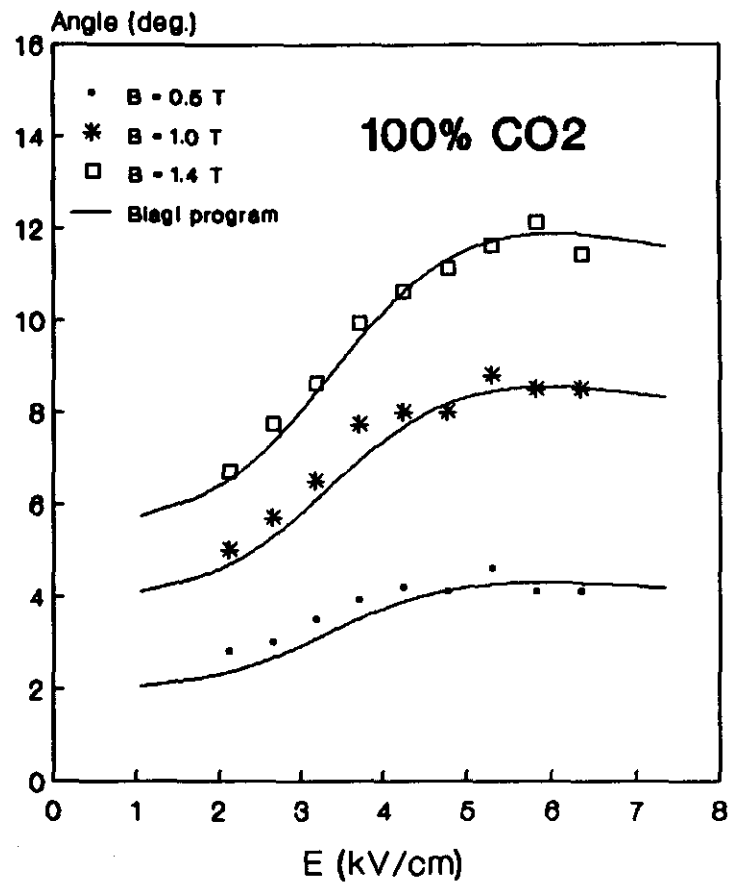
Lorentz angle



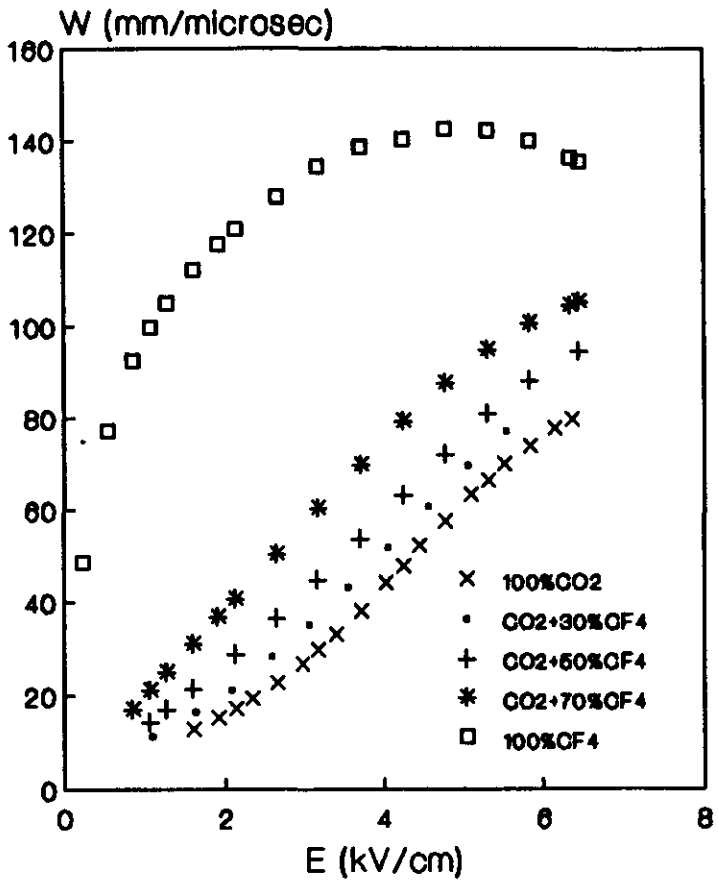


Lorentz angle

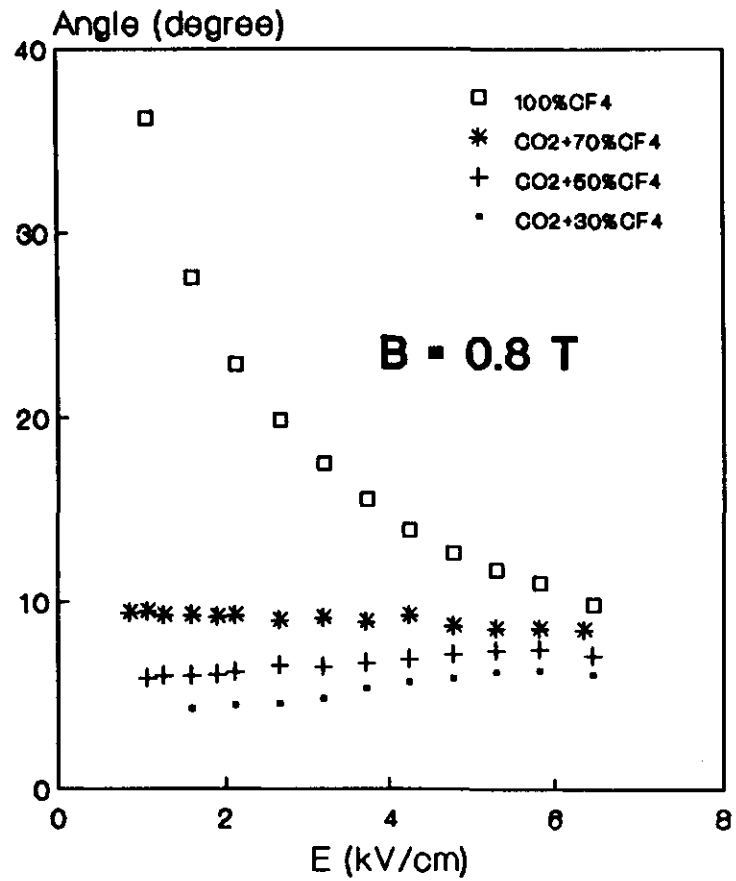




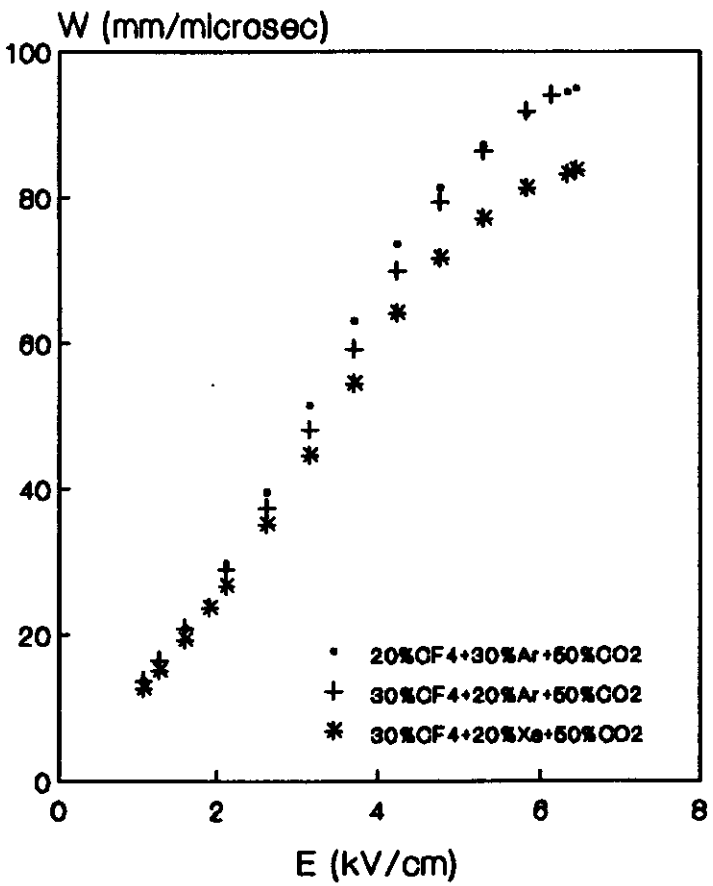
Drift velocity



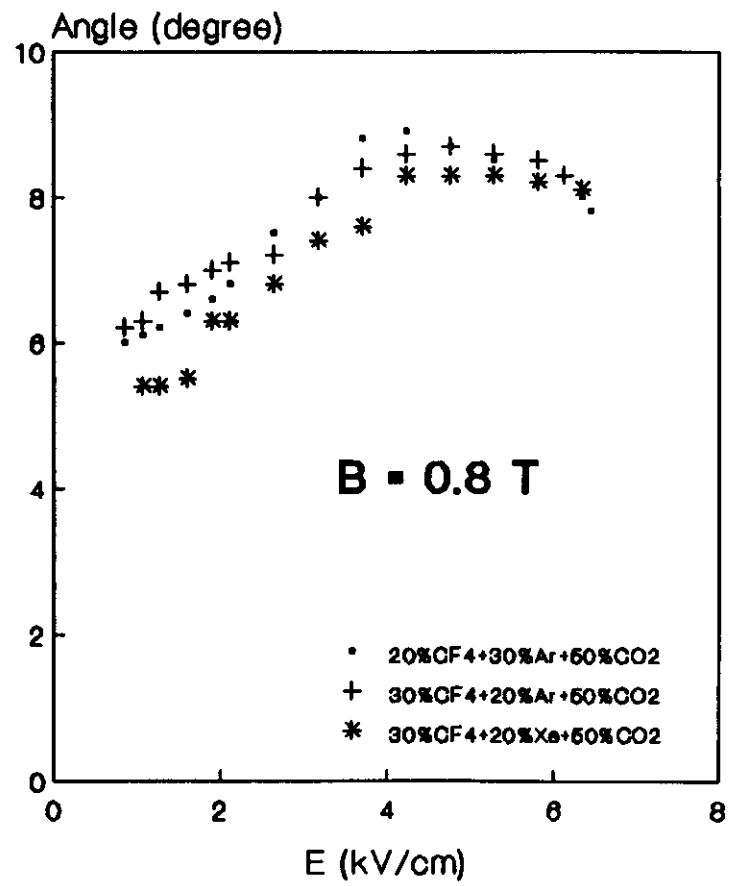
Lorentz angle



Drift velocity



Lorentz angle



Neutron Studies

L. Osborne

Neutron Studies

1) Find Sensitivity of Chambers to:
   - High Energy (>5 Kev) neutrons
   - Capture Gammas - direct
     - delayed
   - Thermal neutrons - activation

2) Minimize Sources - pessimistic M.C.
   - Calorimeters (more light elements)
   - Flux Concentrator (open hole)
   - Beam tube (enlarge)
   - Bottle effect (minimize end material)
   - Outside

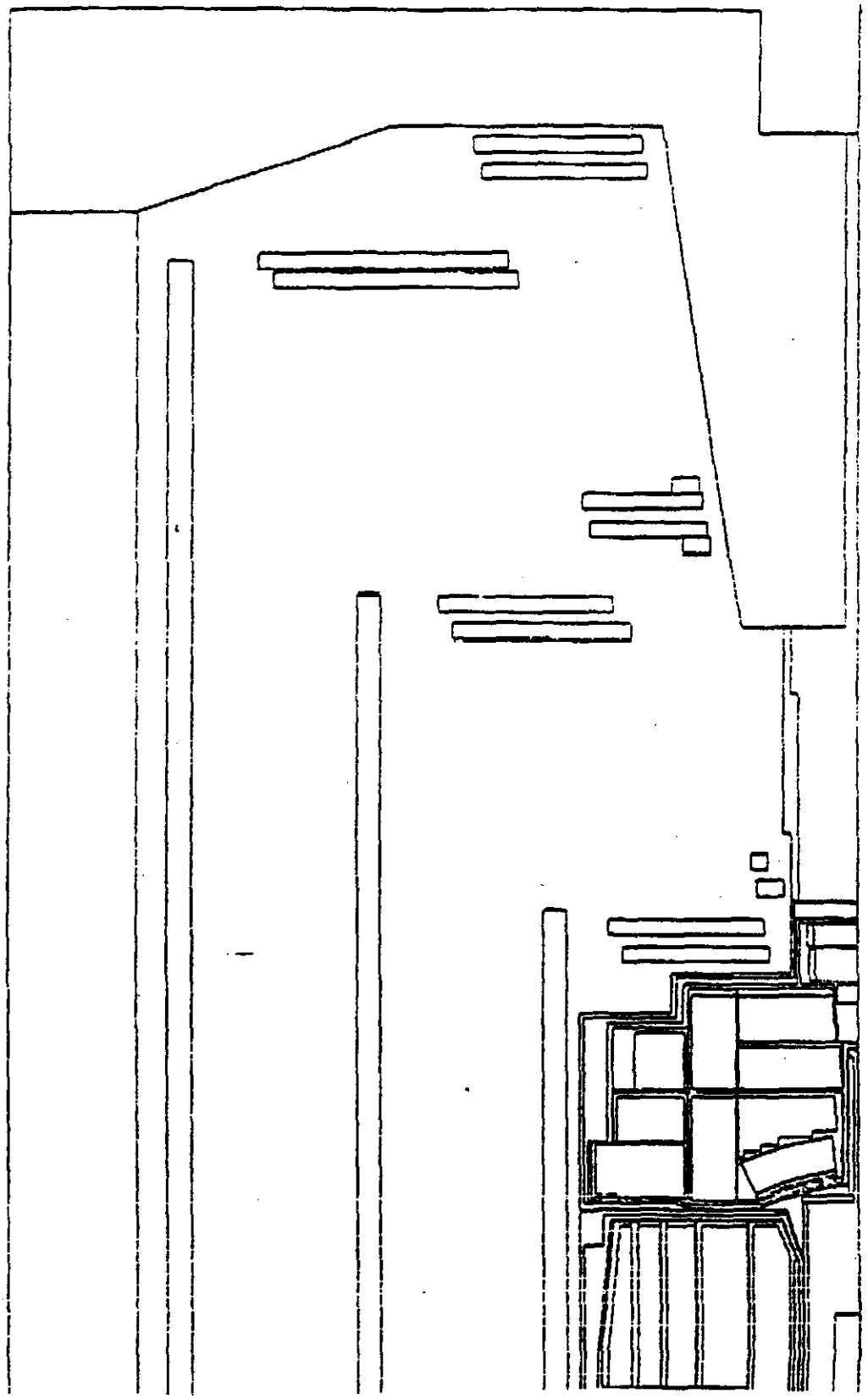
3) Examine effect of Shields
   - Moderator (e.g. Poly)
   - Neutron capturer (e.g. Boron)
   - Lead for gammas
   - Depth & Placement of Shield

4) Propose Solutions - with experts

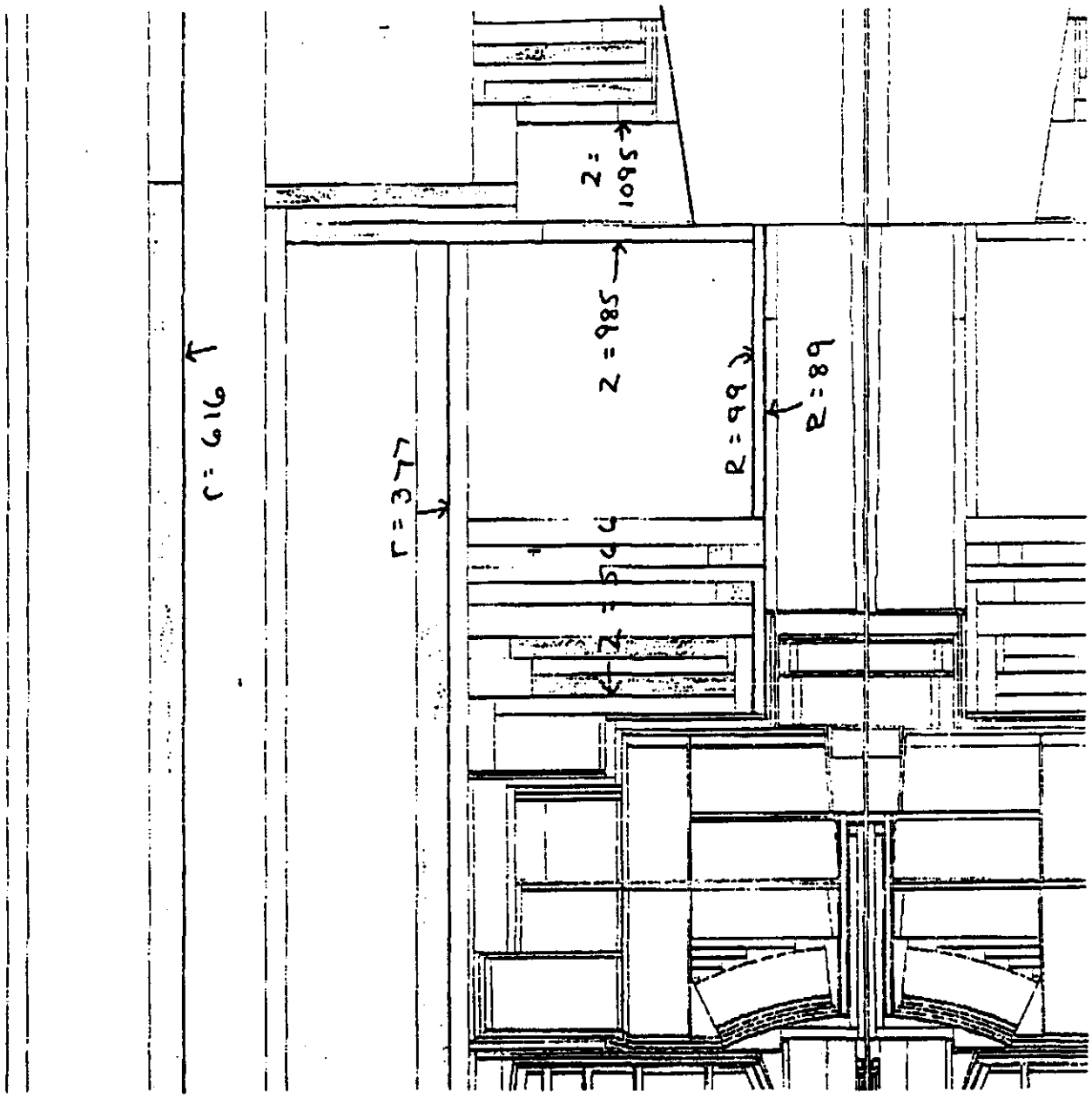
[illegible]

1

From Laurie Waters



(3)



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SEGMENTATION

PROBID - 8/30/92 10 52 50
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(0.000000, 1.000000, 0.000000)
ORIGIN
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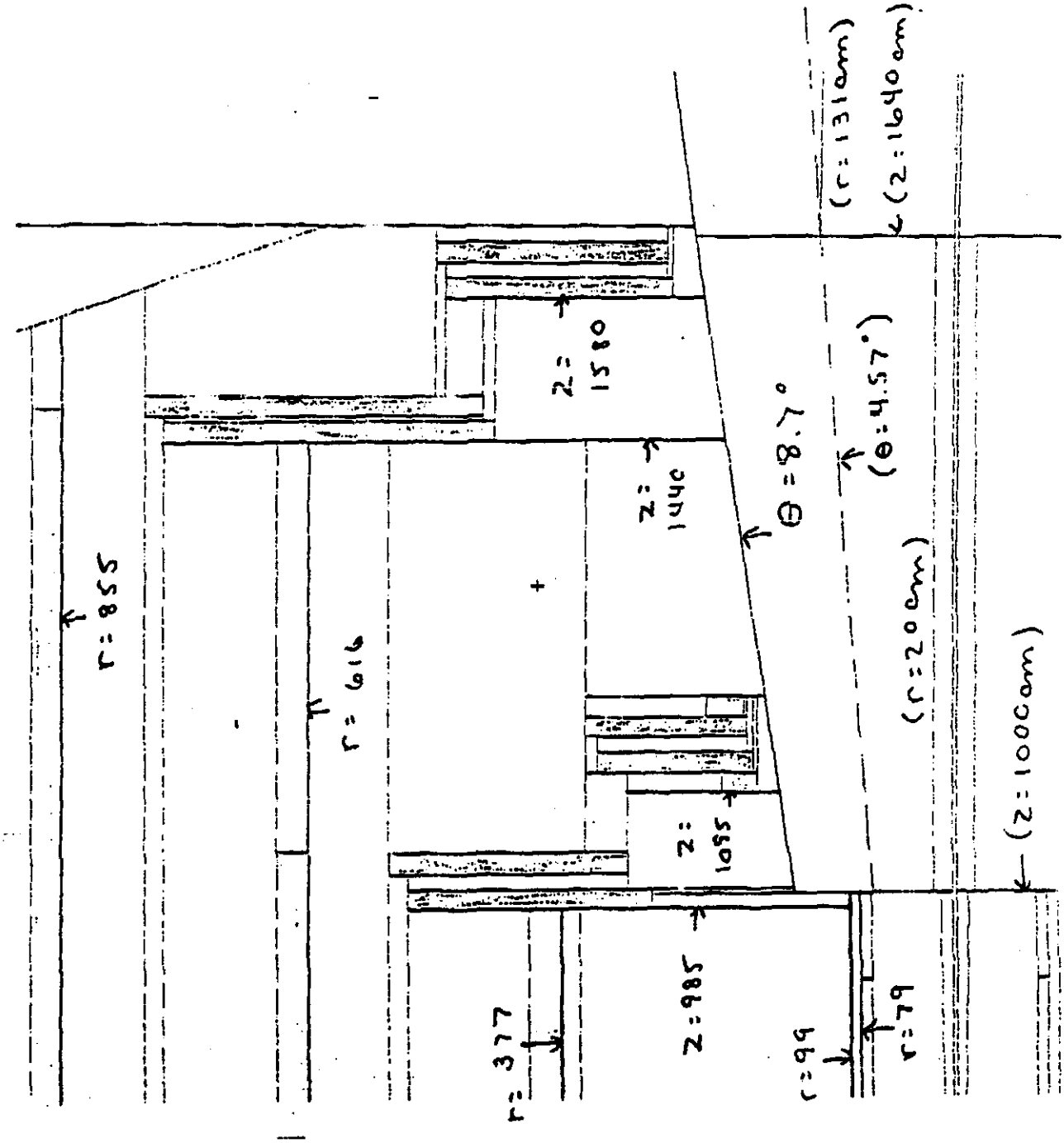
EXTENT = (500.00, 500.00)

2



8/30/92 10 52 15
GEM SIMULATION FINE
SEGMENTATION

PROBID - 5/30/92 10 51 21
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{ 0.000000, 1.000000, 0.000000}
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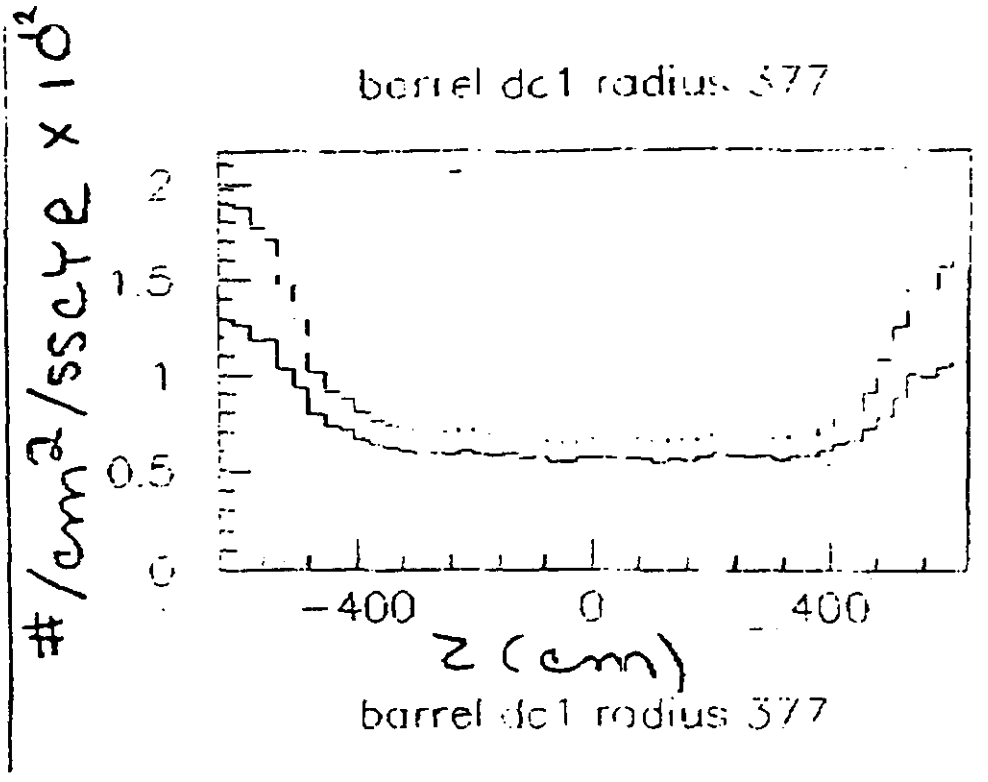
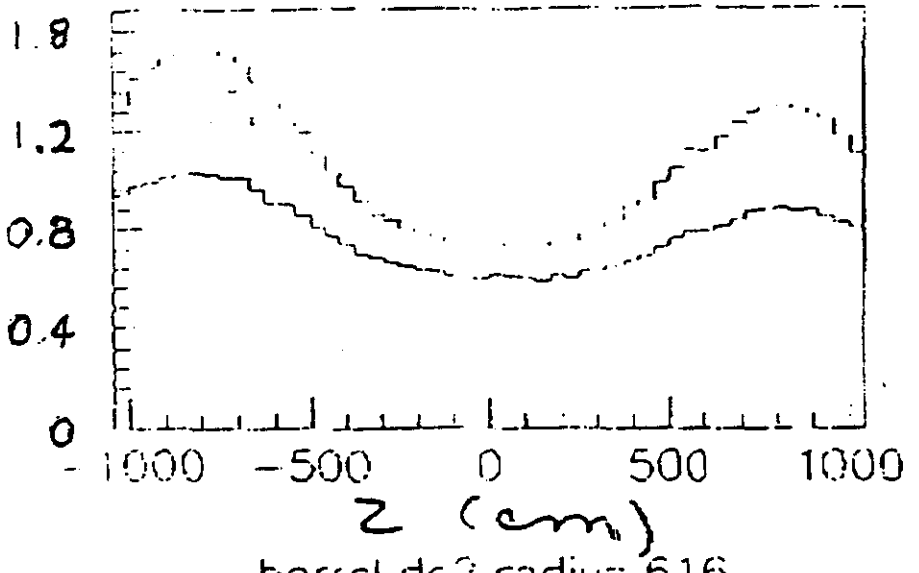


barrel dc1 radius 377



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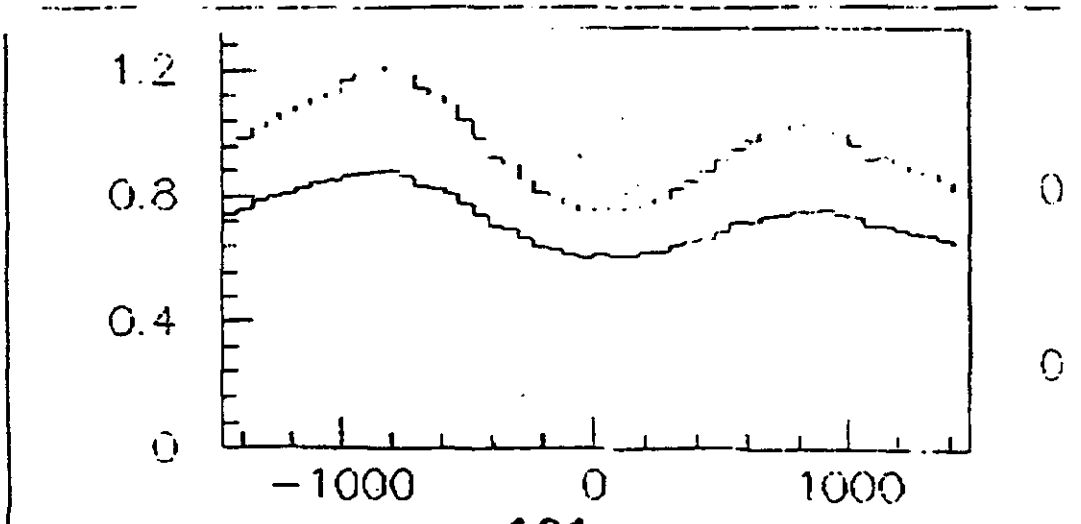
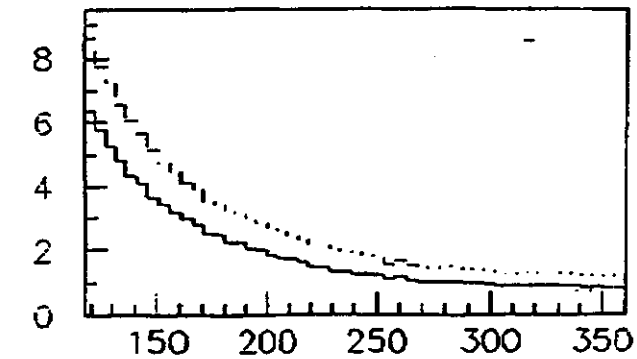
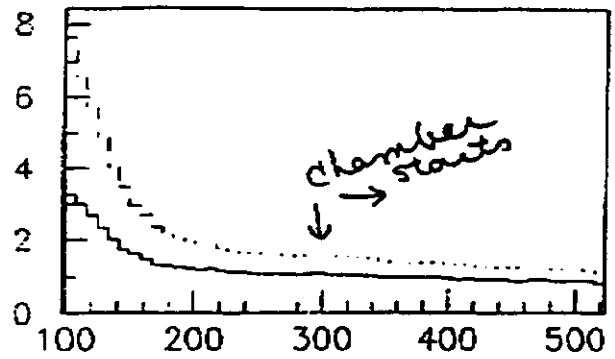


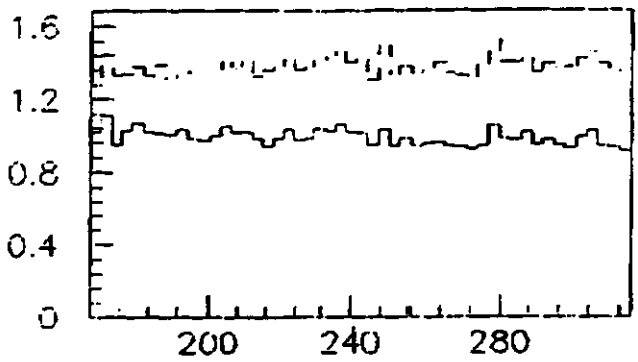
barrel dc3 radius 855



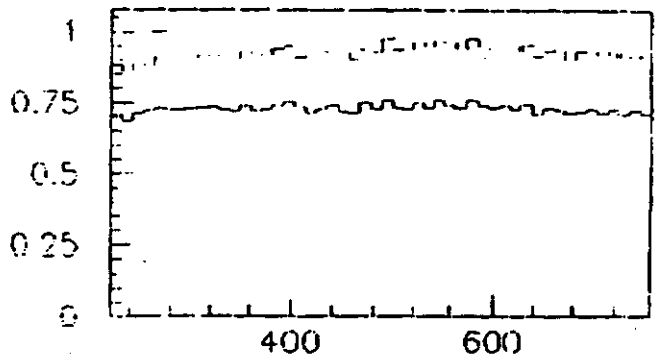
chamber z 566



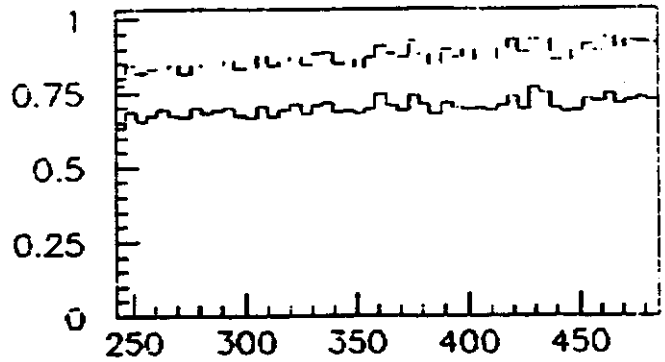
chamber z 985



chamber z 1095

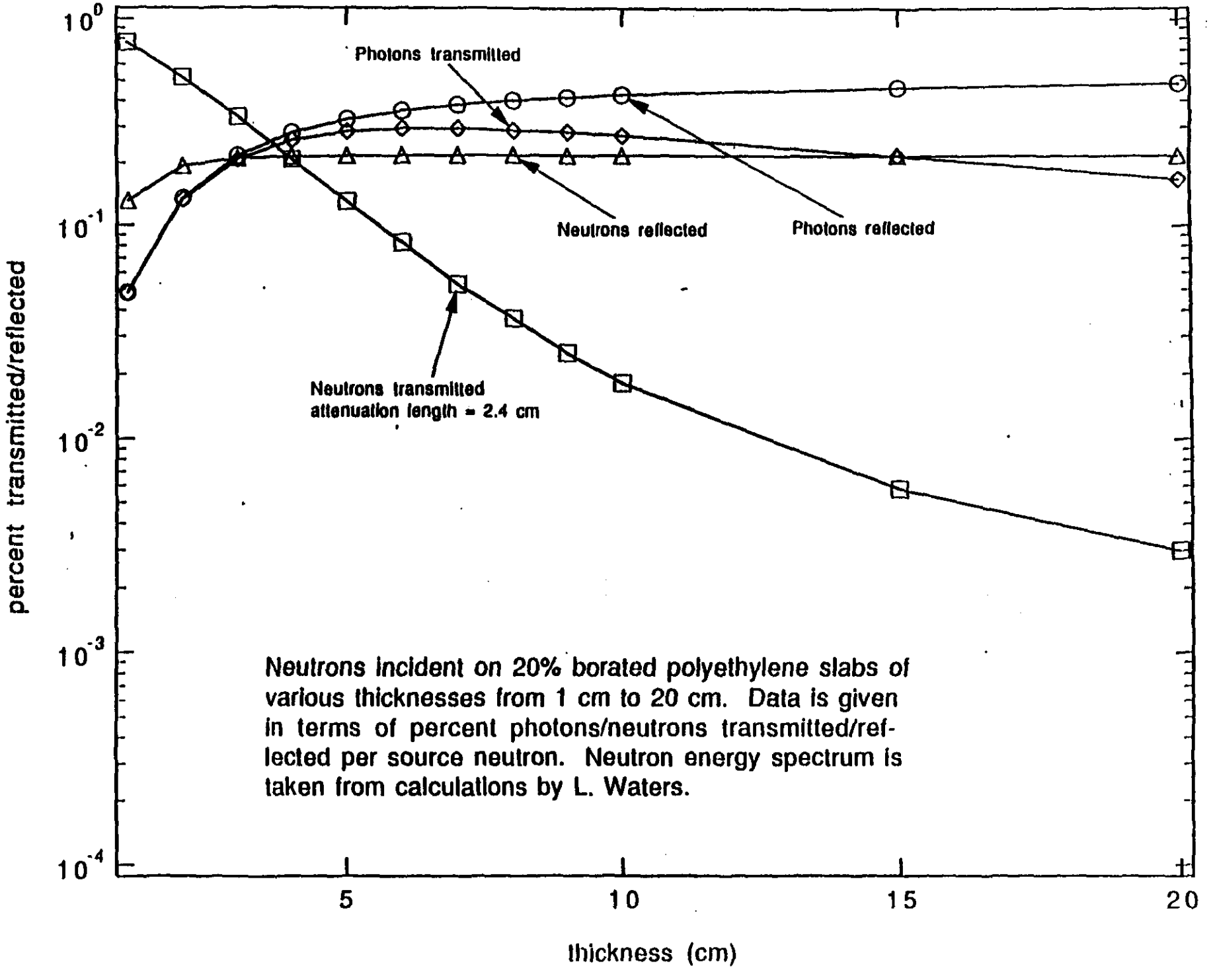


chamber z 1440



chamber z 1580

Figure 5


Photons transmitted
Neutrons reflected
Photons reflected
Neutrons transmitted
attenuation length = 2.4 cm
Neutrons incident on 20% borated polyethylene slabs of various thicknesses from 1 cm to 20 cm. Data is given in terms of percent photons/neutrons transmitted/reflected per source neutron. Neutron energy spectrum is taken from calculations by L. Waters.
percent transmitted/reflected
thickness (cm)
10^0
10^{-1}
10^{-2}
10^{-3}
10^{-4}
5
10
15
20

Compendium of Neutron Spectra and Detector Responses for Radiation Protection Purposes

INTERNATIONAL ATOMIC ENERGY AGENCY, VIENNA, 1990

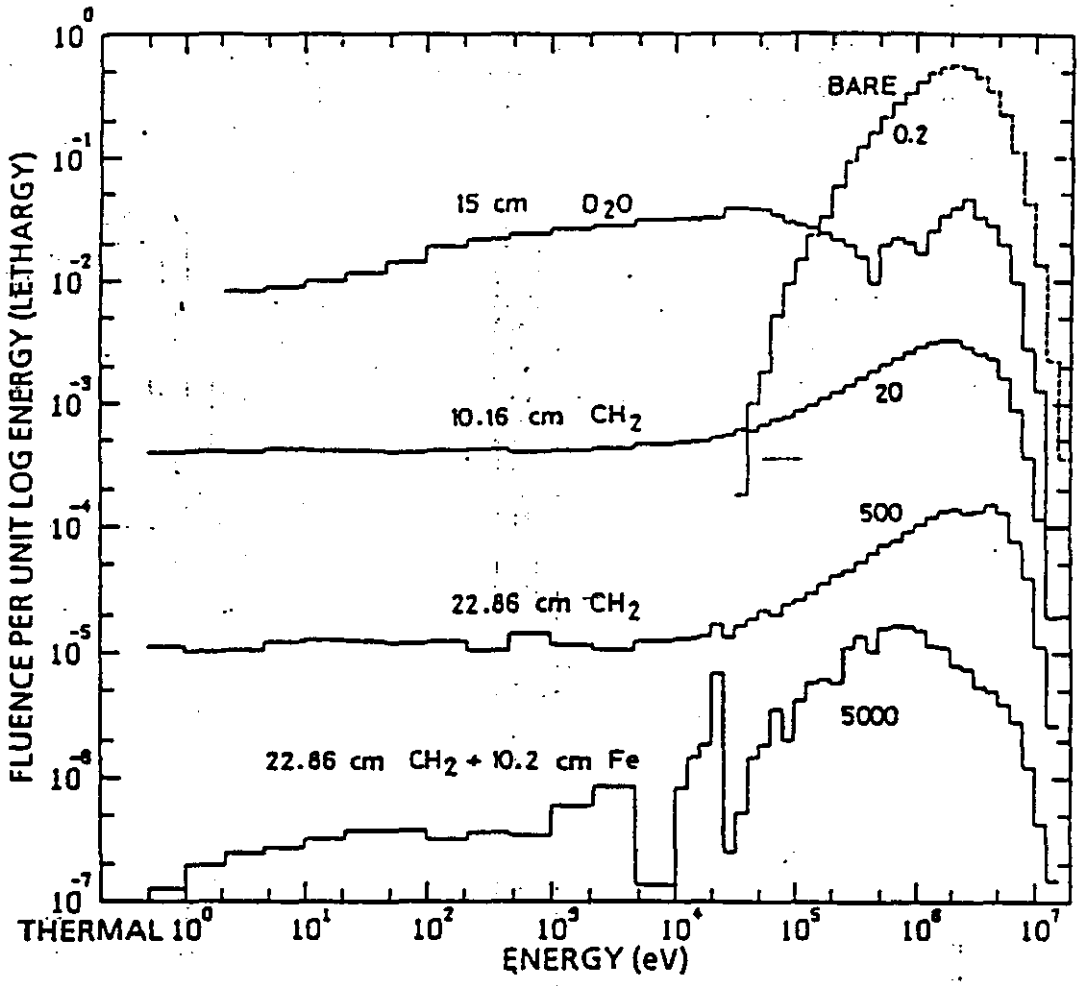


FIG. 4-1. Bare and moderated Cf-252 spectra.

TART Calculations of Neutron Attenuation and Neutron-induced Photons on 5% and 20% Borated Polyethylene Slabs

Craig R. Wuest

Lawrence Livermore National Laboratory

August 28, 1992

Abstract

The coupled neutron/photon transport code TART has been used to calculate the attenuation of neutrons and the production of induced photons for neutrons incident on 5% and 20% borated polyethylene slabs. The neutron attenuation lengths are found to be 2.4 cm and 2.9 cm for 5% and 20% borated polyethylene, respectively.

1. Introduction

The coupled neutron/photon transport Monte Carlo transport code TART[1] has been used to examine the effects of neutron shielding thicknesses for neutron attenuation and neutron-induced photons. Slabs of borated polyethylene were modeled with cylindrical geometry. Slabs 100 cm in radius and variable thickness from 1 to 20 cm were studied. In addition, two different mixtures of borated polyethylene were modeled. These mixtures were provided by Reactor Experiments, Inc.[2] and are listed in Table I.

200,000 neutrons histories were generated for each calculation. Neutrons were incident along the axis of the cylindrical slabs in a beam of zero radius. The neutrons were sampled from an energy spectra provided by L. Waters for neutrons emitted from a model calorimeter. Figure 1 shows the neutron spectrum.

2. Results

A. 5% Borated Polyethylene

Figure 2 shows the results of calculations for 5% borated polyethylene of thicknesses from 1 - 20 cm. The figure shows the percent of neutrons and neutron-induced photons transmitted and reflected from the slabs as a function of thickness. The percentage is calculated with respect to the number of incident source neutrons and is integrated over all energies. A fit to the curve for neutrons transmitted gives an attenuation length of 2.94 cm. Figures 3 and 4 show the photon and neutron energy spectra for both reflected and transmitted photons and neutrons.

B. 20% Borated Polyethylene

Similar calculations were performed for the case of 20% borated polyethylene. Figure 5 shows the percent of neutrons and photons reflected and transmitted from slabs of various thicknesses. From Figure 5 the neutron attenuation length is calculated to be 2.4 cm. Figures 6 and 7 show the photon and neutron energy spectra, respectively.

3. Discussion

In general, borated polyethylene is seen to reduce the amount of transmitted neutrons in an exponential fashion as a function of thickness. On the other hand, transmitted and reflected photons and reflected neutrons tend to approach constant values for slab thicknesses greater than about 5 cm.

Surprisingly there is little difference between the 5% and 20% mixtures of borated polyethylene. This is presumably because of the decreased moderating of neutrons in the 20% mixture. There is a difference in the energy spectra of neutrons transmitted and reflected for the two mixtures, with the 20% mixture attenuating more of the low energy neutrons below about 100 eV. The reduction is about a factor of 10 between 10 and 100 eV and about a factor of 100 below 10 eV. There is little difference in the neutron-induced photon energy spectra.

4. Conclusions

These calculations show that the effectiveness of neutron attenuation is a complicated function of the amount of boron loading in the shielding material. There appear to be competing effects of neutron moderation provided by carbon and hydrogen, and neutron capture provided by boron. These calculations will be continued for other mixtures (10% and 15%) of borated polyethylene as well as boron mixtures in non-flammable binders.

References:

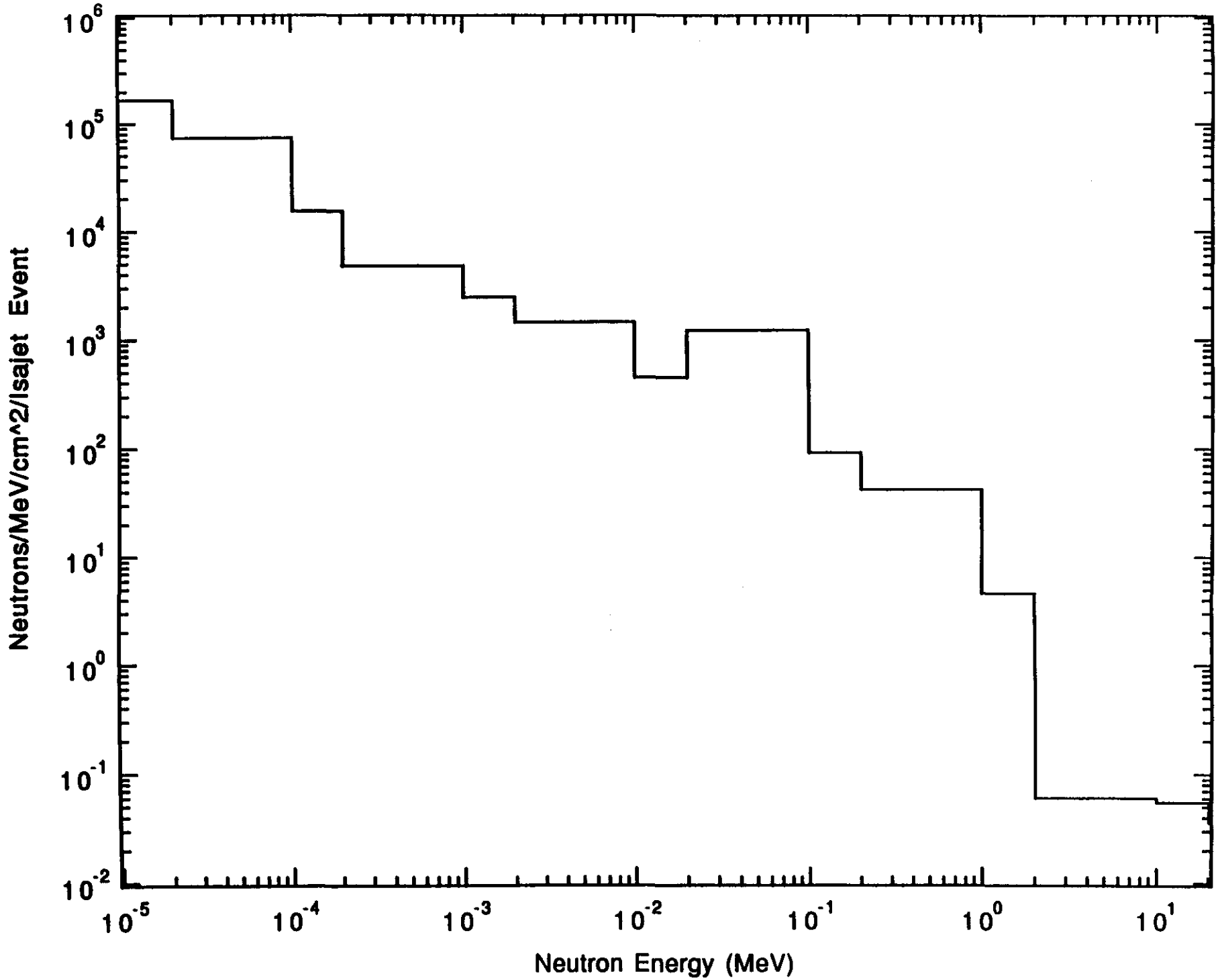
1. J. Kimlinger, N. Monson, and E. Plechaty, "TartNP, A Coupled Neutron-Photon Monte Carlo Transport Code," UCRL-50400 vol.14, 1976.

2. P. Lizak, faxed communication, Reactor Experiments, Inc., 1275 Hammerwood Ave., Sunnyvale, CA 94089, (408) 745-6770.

Table I: Borated Polyethylene Mixtures as provided by Reference (2) numbers are given as weight fractions

Element	5% Borated Polyethylene	20% Borated Polyethylene
H	0.116	0.105
C	0.612	0.680
^{11}B	0.040	0.150
^{10}B	0.010	0.050
Si	N/A	0.0068
O	0.222	0.005
Al	N/A	0.0003
Mn	N/A	0.0001
Fe	N/A	0.0025

Figure 1


Neutrons/MeV/cm^2/Isajet Event
Neutron Energy (MeV)
10^{6}
10^{5}
10^{4}
10^{3}
10^{2}
10^{1}
10^{0}
10^{-1}
10^{-2}
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
10^{0}
10^{1}

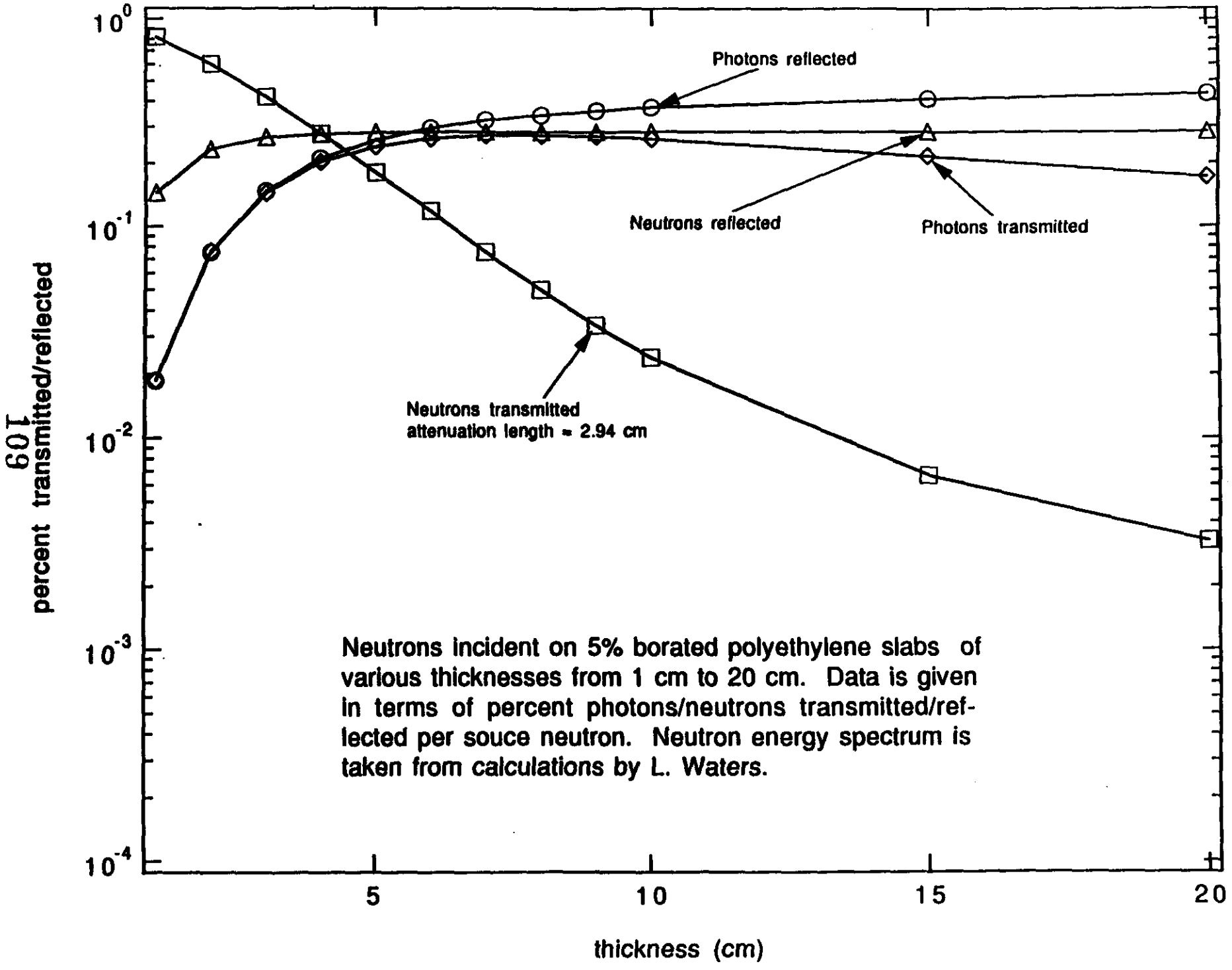

Photons reflected
Neutrons reflected
Photons transmitted
Neutrons transmitted
attenuation length = 2.94 cm
Neutrons incident on 5% borated polyethylene slabs of various thicknesses from 1 cm to 20 cm. Data is given in terms of percent photons/neutrons transmitted/reflected per souce neutron. Neutron energy spectrum is taken from calculations by L. Waters.
percent transmitted/reflected
thickness (cm)
10^0
10^{-1}
10^{-2}
10^{-3}
10^{-4}
5
10
15
20

Figure 3

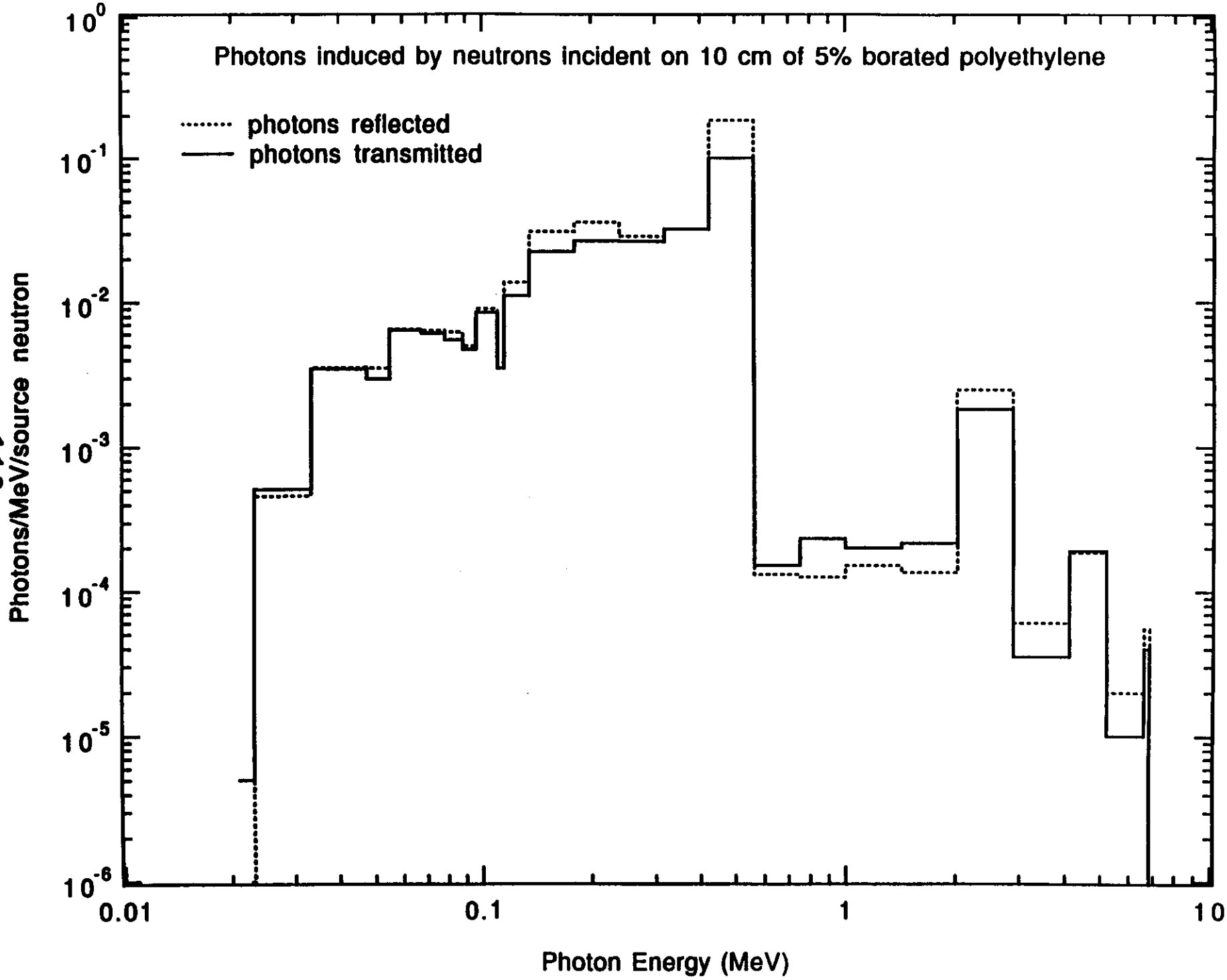

Photons induced by neutrons incident on 10 cm of 5% borated polyethylene
photons reflected
photons transmitted
Photons/MeV/source neutron
Photon Energy (MeV)
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
0.01
0.1
1
10

Figure 4

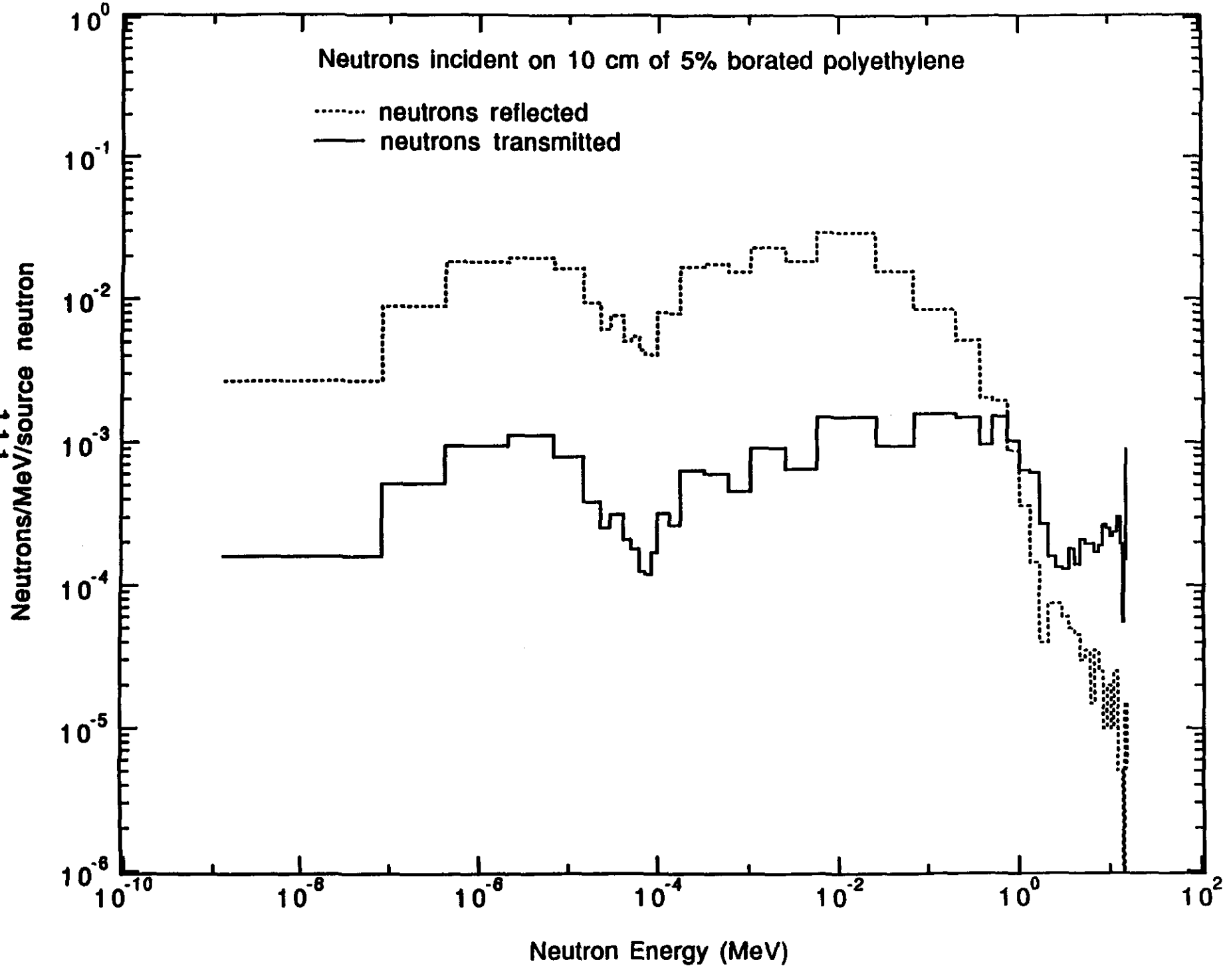

Neutrons incident on 10 cm of 5% borated polyethylene
neutrons reflected
neutrons transmitted
Neutrons/MeV/source neutron
Neutron Energy (MeV)
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-10}
10^{-8}
10^{-6}
10^{-4}
10^{-2}
10^{0}
10^{2}

Figure 5

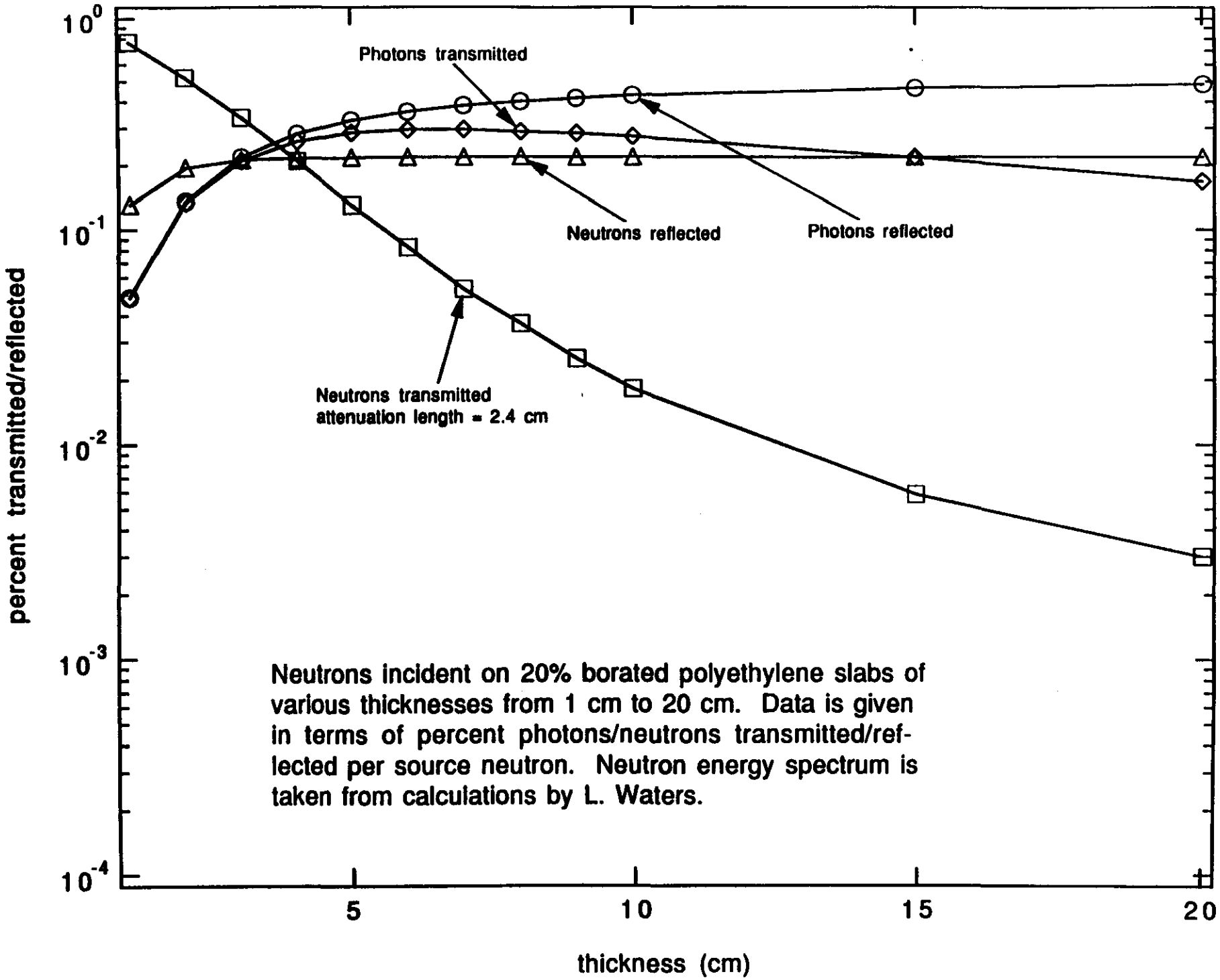

Photons transmitted
Neutrons reflected
Photons reflected
Neutrons transmitted
attenuation length = 2.4 cm
Neutrons incident on 20% borated polyethylene slabs of various thicknesses from 1 cm to 20 cm. Data is given in terms of percent photons/neutrons transmitted/reflected per source neutron. Neutron energy spectrum is taken from calculations by L. Waters.
percent transmitted/reflected
thickness (cm)
10^0
10^{-1}
10^{-2}
10^{-3}
10^{-4}
5
10
15
20

Figure 6

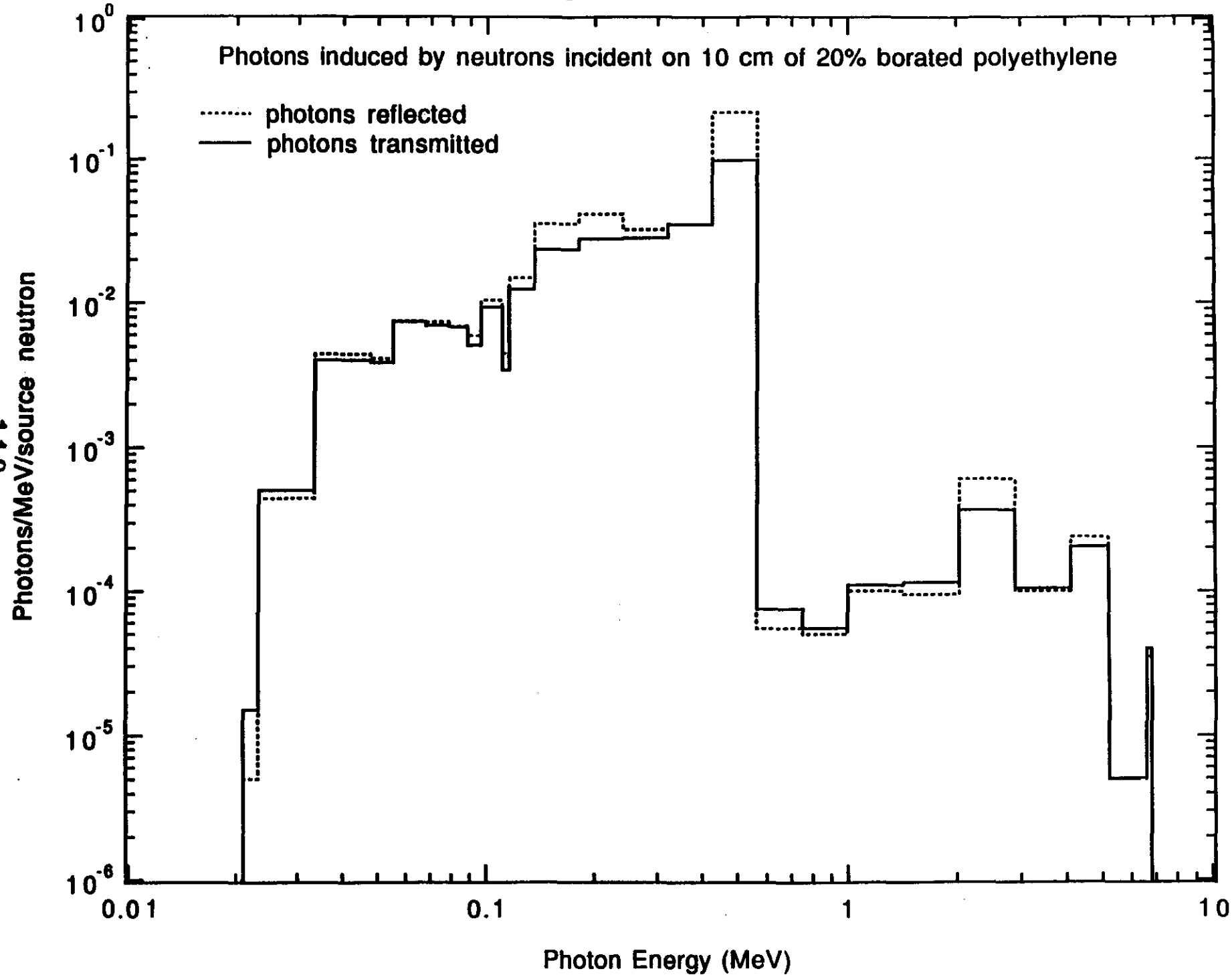
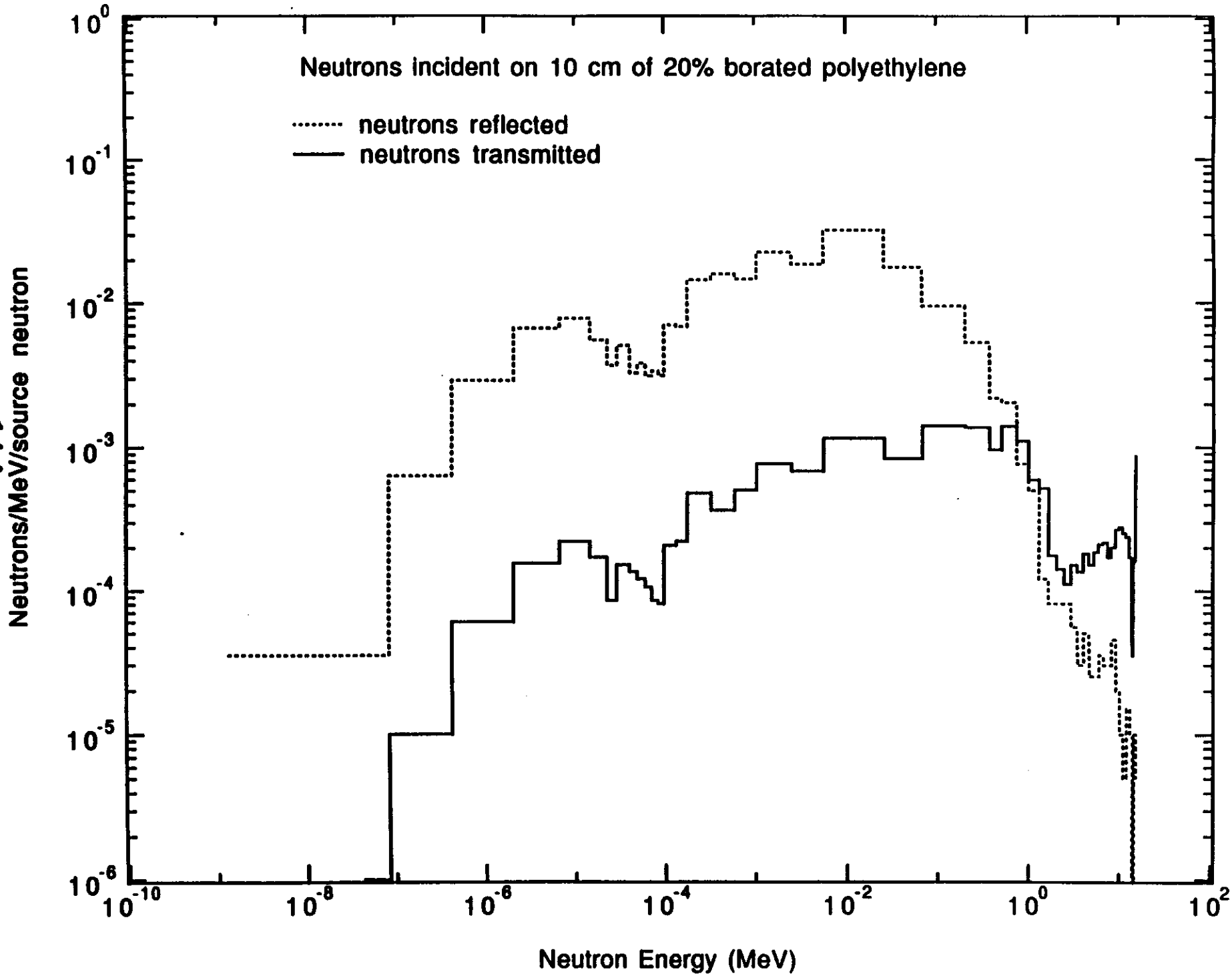

Photons induced by neutrons incident on 10 cm of 20% borated polyethylene
photons reflected
photons transmitted
Photons/MeV/source neutron
Photon Energy (MeV)
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
0.01
0.1
1
10

Figure 7


Neutrons incident on 10 cm of 20% borated polyethylene
neutrons reflected
neutrons transmitted
Neutrons/MeV/source neutron
Neutron Energy (MeV)
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-10}
10^{-8}
10^{-6}
10^{-4}
10^{-2}
10^{0}
10^{2}

Hi Muon Neutron Committee,

Here are a few miscellaneous plots. The GEM run I hope will be finished by tomorrow, but I can't guarantee it. I am running DTUJET events into the BASELINE 1 configuration and getting fluences for most of the chambers, including the barrel region. The results can then be compared with the ISAJET TWOJET events I have already run.

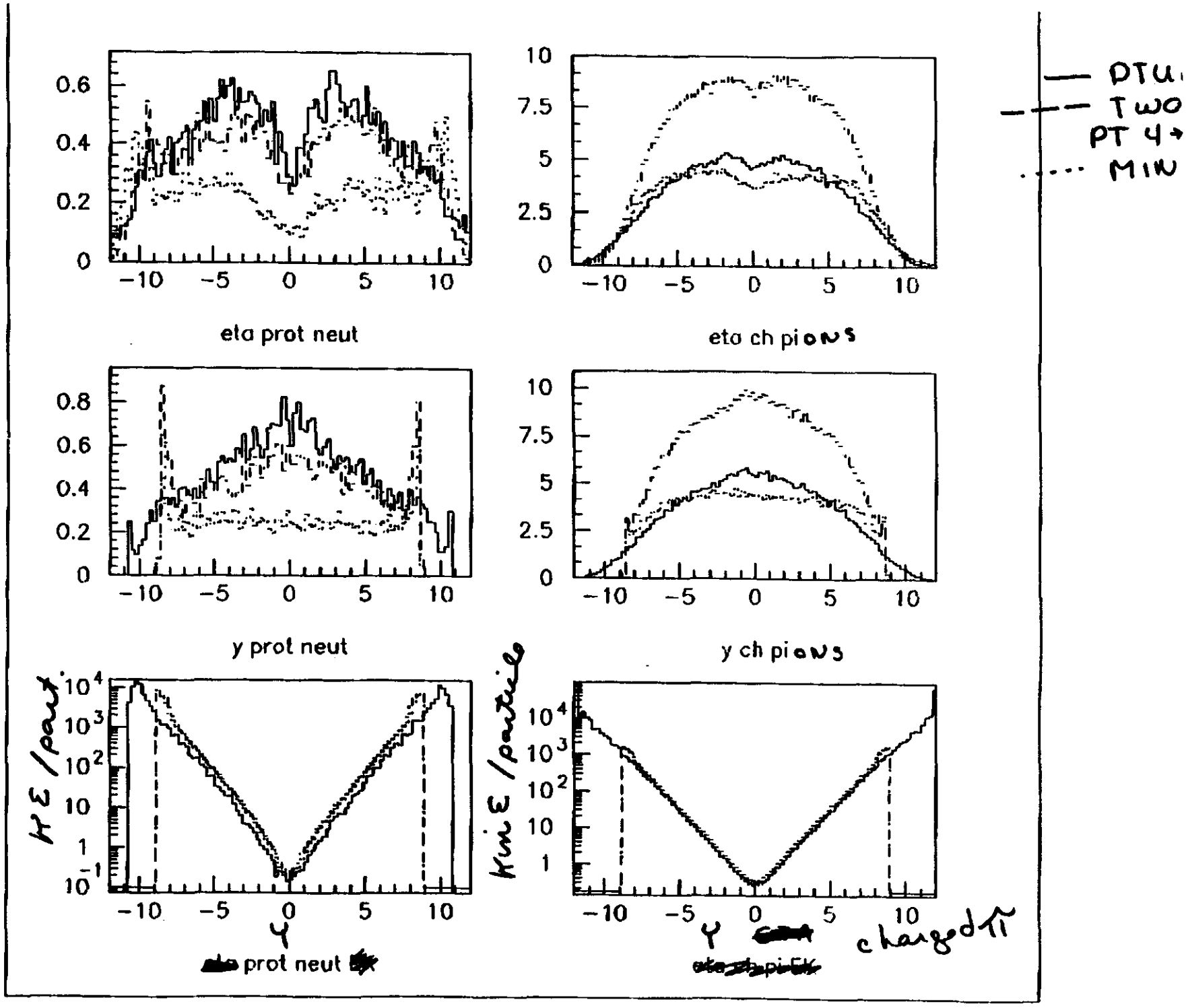
Here are what this set of plots is:

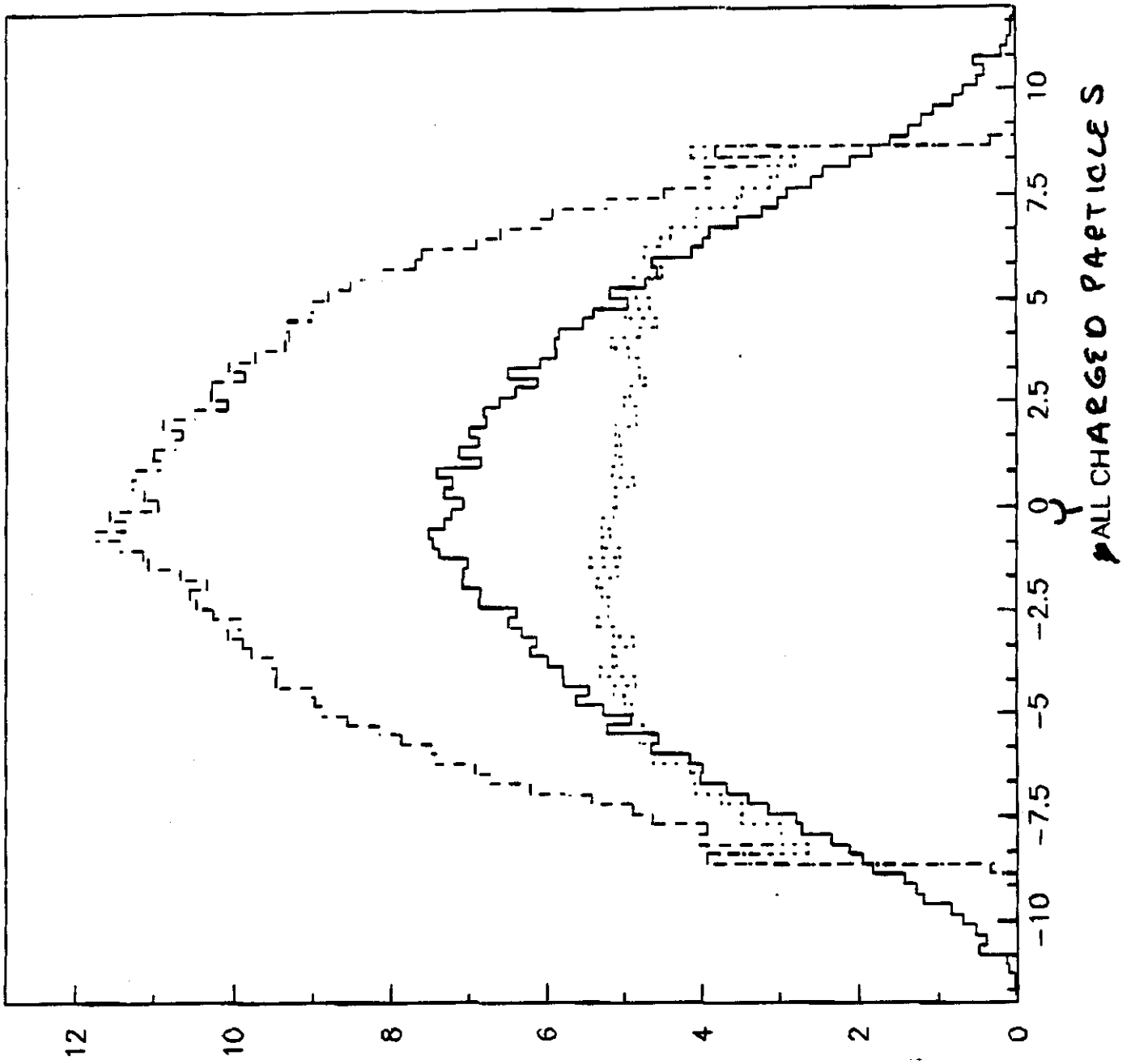
page 1 and 2.
two pages of comparisons of DTUJET, ISAJET TWOJET and MINBIAS. The TWOJET by far gives the largest dN/dy and dN/deta in the central region. The reason that the ISAJET events do not get out to as high rapidities as DTUJET is that ISAJET is a single precision code, while the DTUJET events Nikolai Mokhov wrote out for me are all double precision.

page 3
This is a study just completed for the GEM central tracker, showing the spectrum of photons and neutrons around the silicon tracker. The photons all result from (n,gamma) reactions in nearby materials, most of which is borated poly. (note these are not the regular shower photons, these are just the component coming from neutron capture).
Note the big peak at .48 MeV from the capture on boron 10. Although this is done for the central tracker region, I think the spectrum will be typical of what would go into a muon chamber if you start putting borated poly close by.

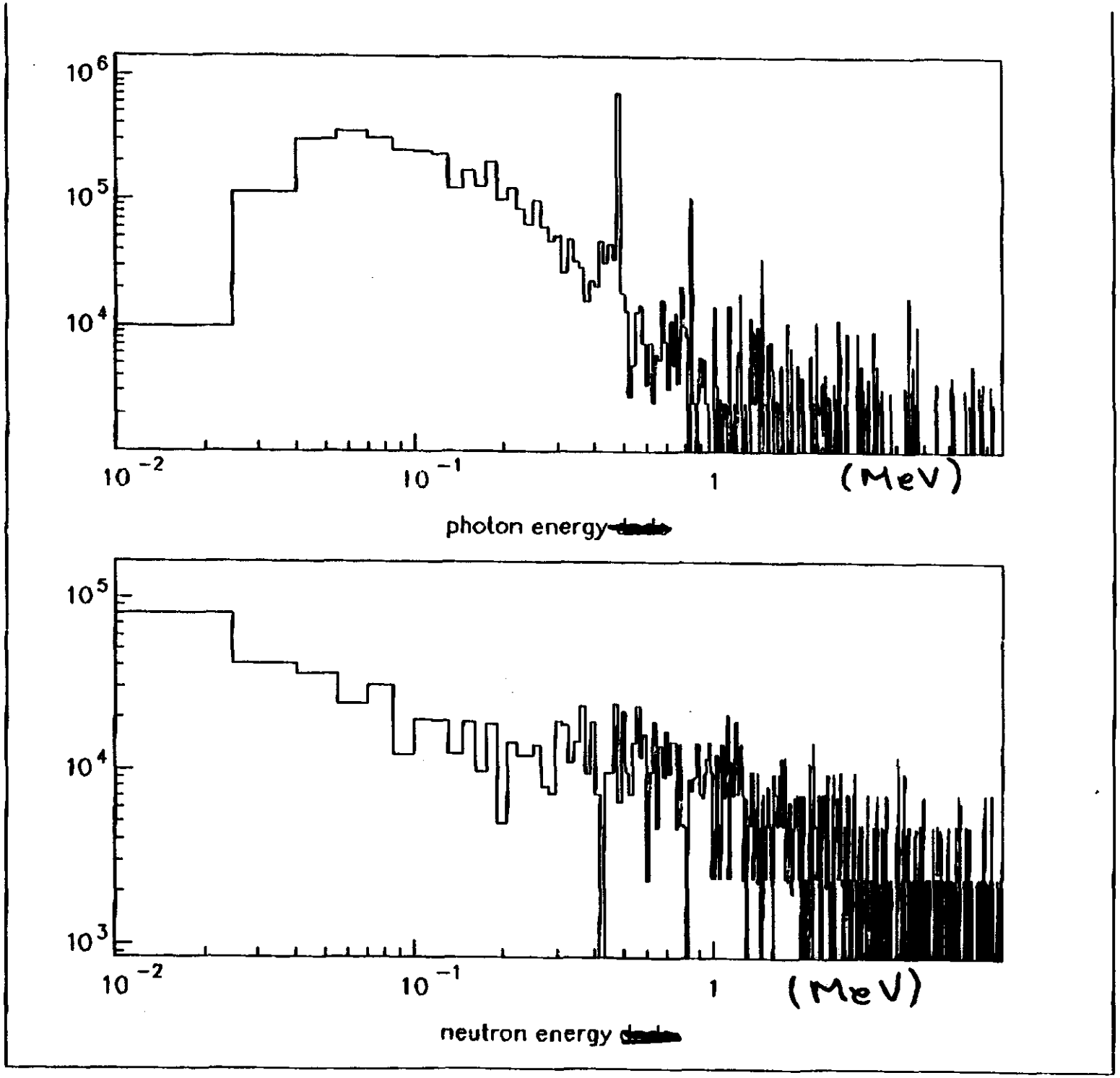
page 4
This is a figure showing the effect of various thicknesses of shielding materials on the thermal neutron flux for 2.6 MeV neutrons. I am not entirely sure what the 2.6 MeV neutrons were incident on, maybe just the b-poly. Anyway, be careful, because the is the effect on the thermal neutron component only. I include page 5 which shows a study again done for the gem central traker which shows that above about 10 MeV, b-poly doesn't do much for neutron supression.

Laurie


eta prot neut
eta ch pions
y prot neut
y ch pions
KE /part
Kin E /particle
Y
charged π
DTU
TWO
PT 4+
MIN



AUG-24-92 MON 12:39 P.04/07



in 6 centro silicio track

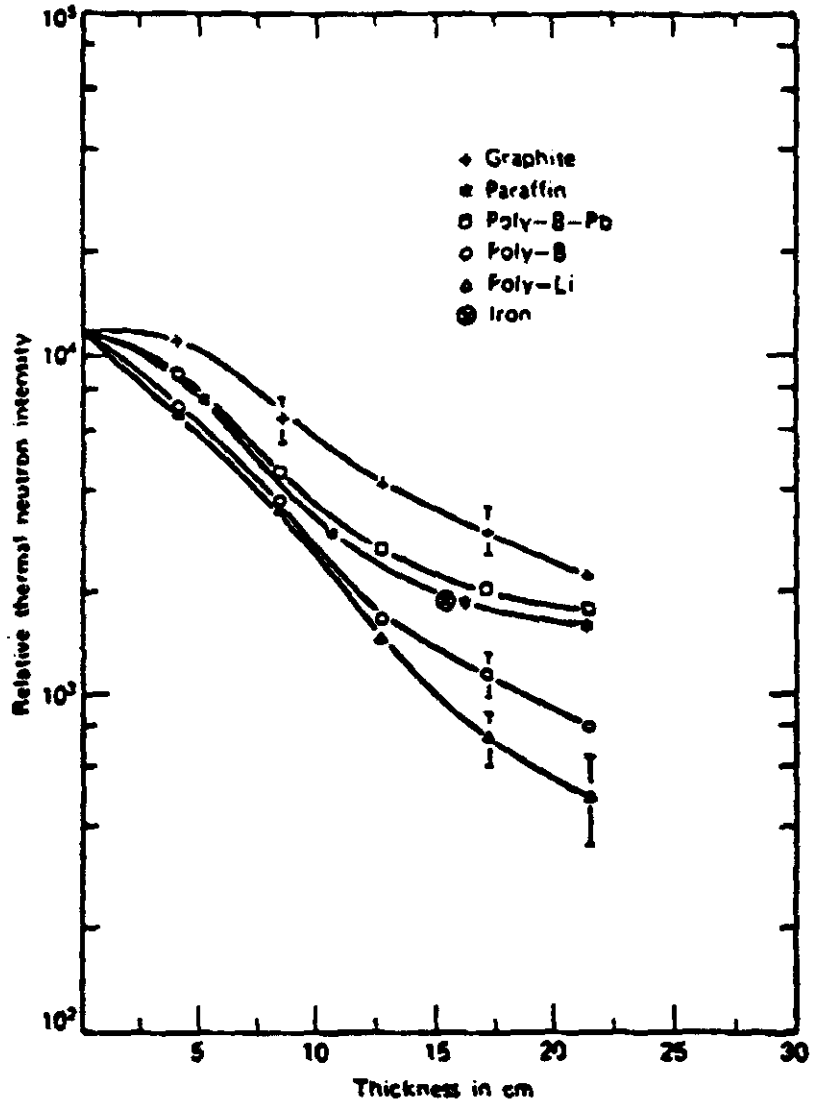


FIGURE 20-7. The relative effectiveness of different shielding materials for 2.6 MeV neutrons as indicated by the thermal neutron flux for various thickness. (From Gujrathi and D'Auria[12].)

6EM DESIGN I

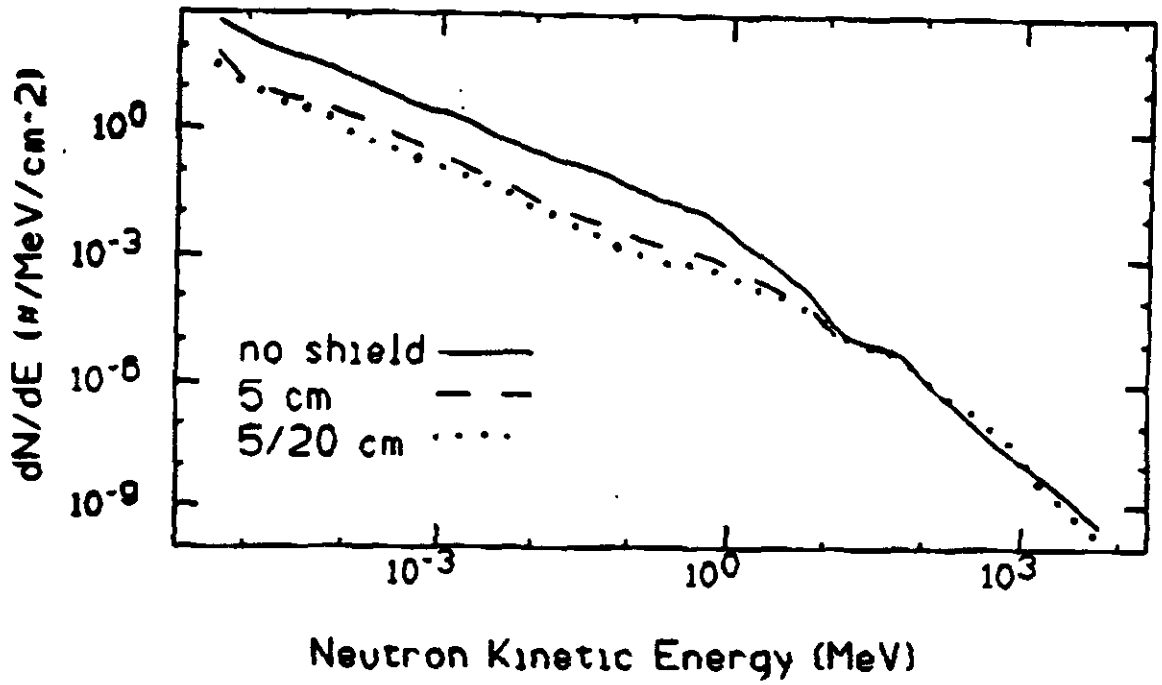


Figure 5: Differential neutron fluence is compared for the no shield, 5 cm and 5/20 cm cases. Results are per SSC minimum bias event. **waters/4-4-92**

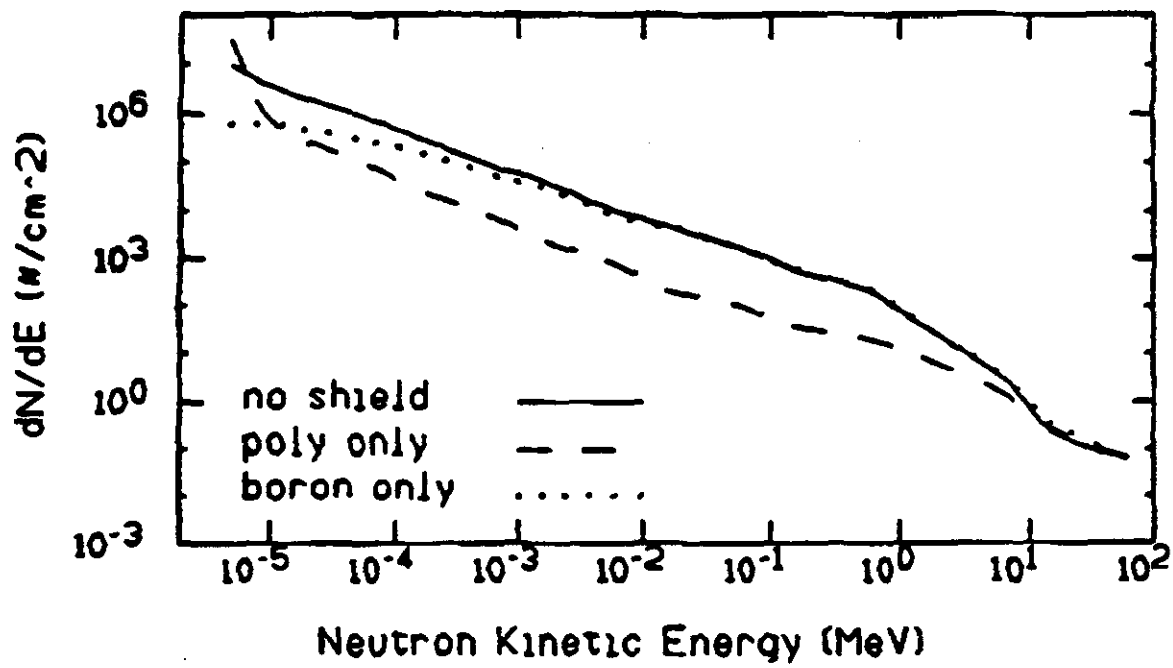


Figure 6: The thermalization effects of shielding composed of just polyethylene, and the supression of the thermal neutrons with a shield composed of just boron are compared to the no shield case. Results are per SSC minimum bias event.

waters/4-4-92

Passive 3 Lamda

R. McNeil

Effect of Passive Absorber before the Muon System

To reduce costs it has been suggested to not instrument the final 3λ of the Calorimeter

Given an incident muon momentum, we can estimate the avg energy loss by a muon through passive calorimetry. In this case, the fluctuations in the energy loss ΔE_{Loss} enters into the muon measurement uncertainty

$$\left.\frac{\Delta P}{P}\right|_{TOTAL} = \left.\frac{\Delta P}{P}\right|_{\substack{\mu\ mom \\ meas}} \oplus \left.\frac{\Delta E_{Loss}}{P}\right|_{\substack{Pass \\ Cal}}$$

If we can measure E_{Loss} in Calorimeter we can perhaps reduce ΔE_{Loss}.

Strategy: Try to reconstruct E^{μ}_{INC}

$$E^{\mu} = E^{\mu}_{OUT} + \underbrace{E^{\text{Active Cal}}_{meas}}_{\text{resolution}} + \langle E^{\text{Passive Cal}}_{Loss} \rangle$$

Compare $\frac{\sigma_{E^{\mu}}}{E^{\mu}}$ for

1. All Passive Absorber

2. ~~All~~ Active Calorimetry

3. 9λ Active Cal followed by 3λ Passive Cal

What was simulated:

12λ of Copper (97% vol) + Scint. Fiber (3% vol)

with GEANT for ν^+ of E_{inc} = 10, 20, 50, 100, 500, 1000 GeV.

Determine E_{DEP} is 1ST 9λ and last 3λ.

Can smear E_{DEP} with Cal resolution

$$\frac{\sigma_E}{E} = \frac{A}{\sqrt{E}}$$

Try 2 values for A: 0.2 & 0.35

Try to reconstruct E_ν for 3 cases:

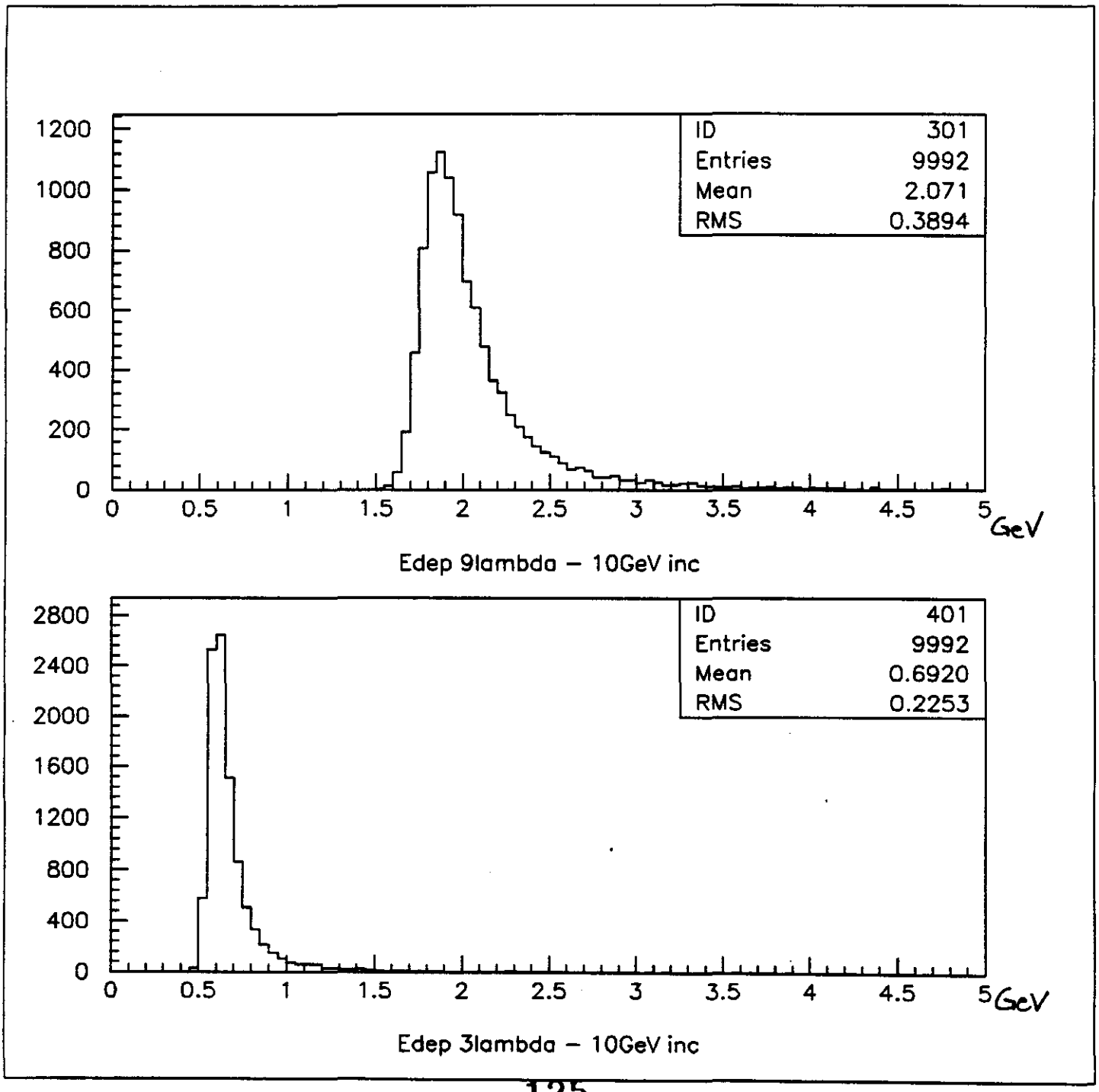
1. $E_\nu = E_\nu^{OUT} + \langle E_{lost} \rangle^{12\lambda}$

2. $E_\nu = E_\nu^{OUT} + E_{meas}^{9\lambda} + \langle E_{lost} \rangle^{3\lambda}$

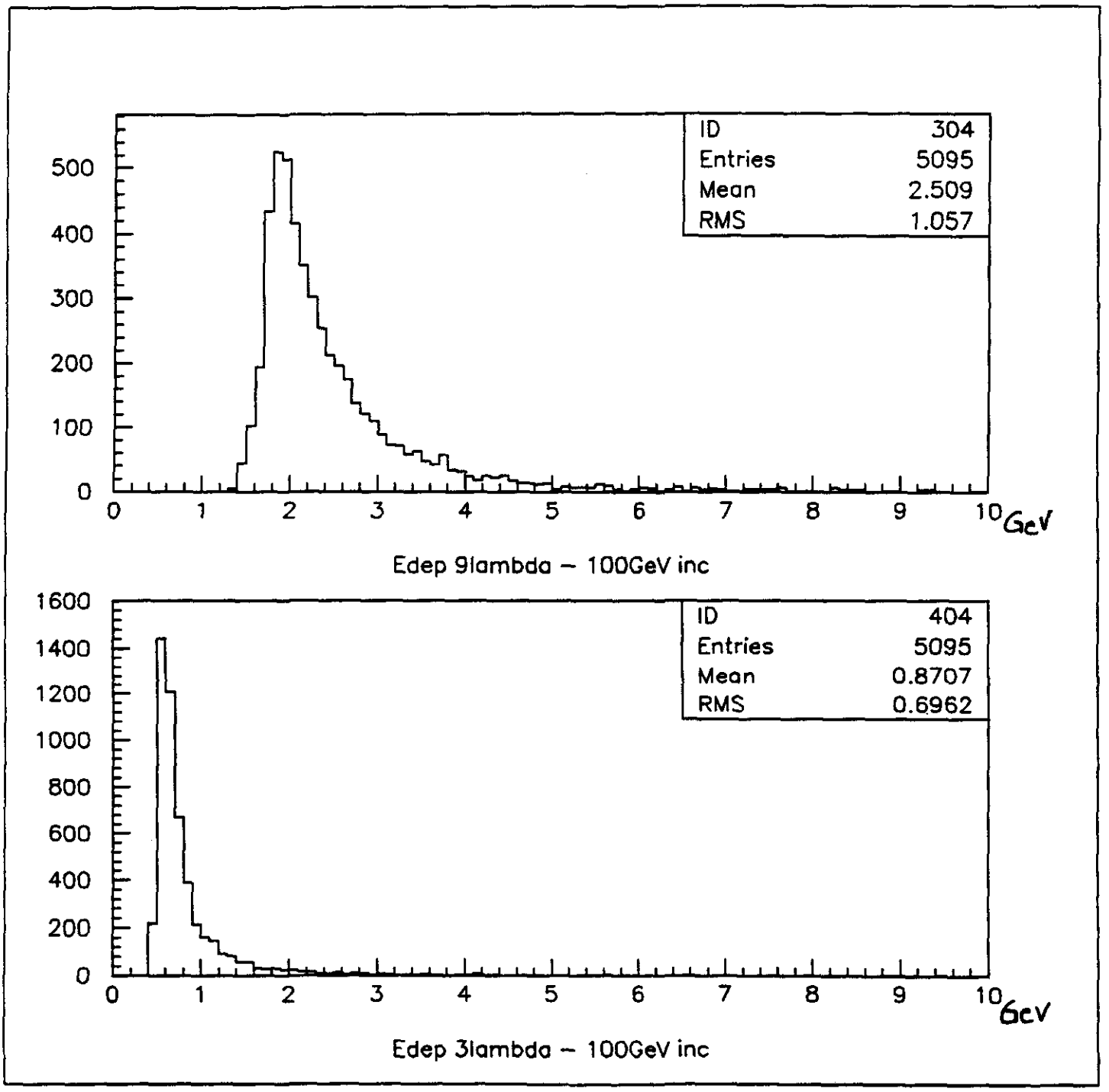
3. $E_\nu = E_\nu^{OUT} + E_{meas}^{12\lambda}$

E_ν^{OUT} is not smeared; consider effect of CAL only

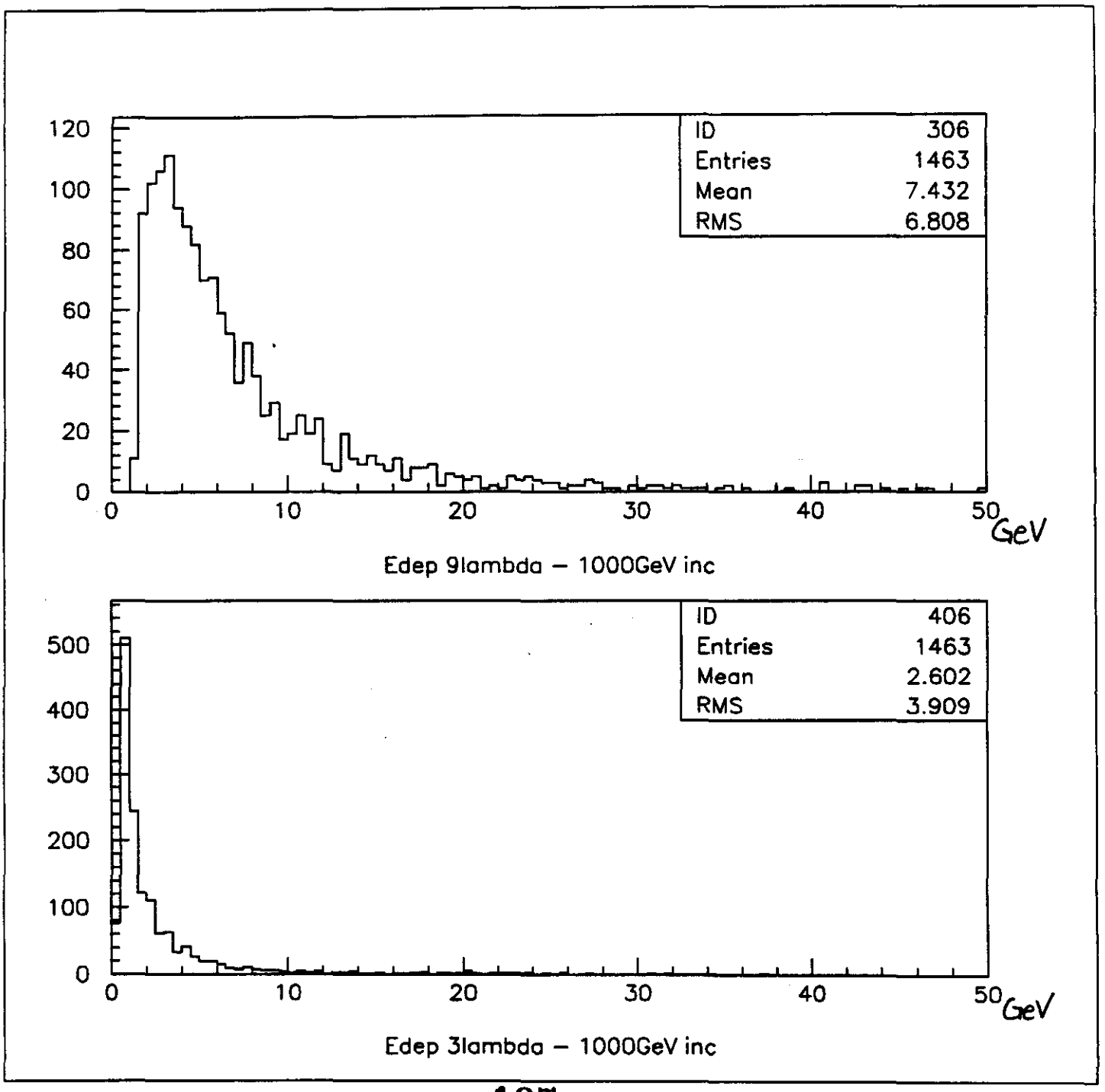
GEANT Simulation of 10GeV ν
Through 12λ of Cu/scint Calorimeter



GEANT Simulation of 100GeV ν
through 12λ of Cu/Scint Calorimeter



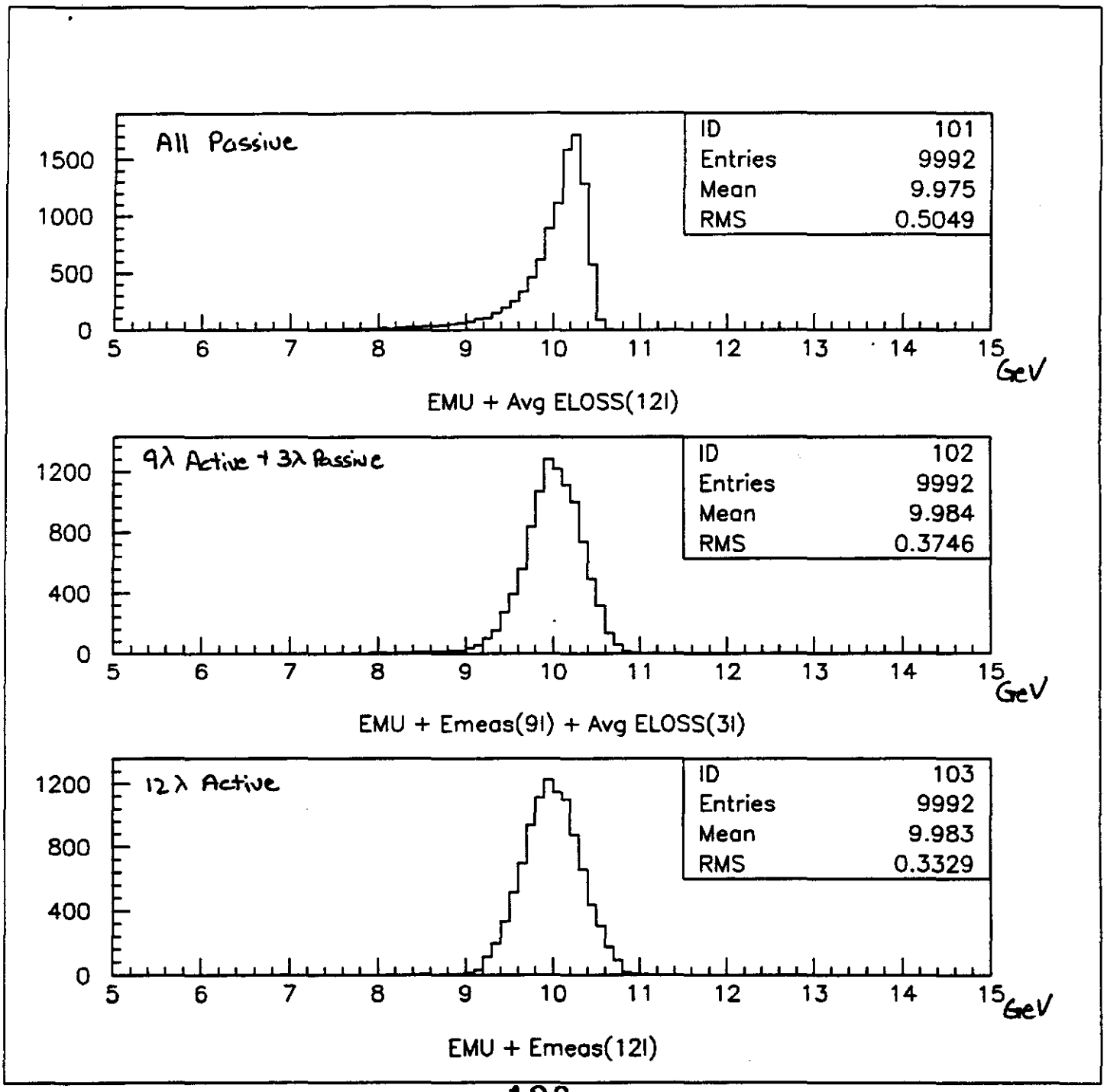
GEANT Simulation of 1TeV ν
through 12 λ of Cu/Scint Calorimeter



GEANT Simulation of 10GeV ν
through 12λ of Cu/Scint Calorimeter

Reconstruct E_ν assuming perfect measurement of E_ν^{OUT}

Active Calorimeter resolution: $\frac{\sigma_E}{E} = \frac{20\%}{\sqrt{E}}$



GEANT Simulation of 100 GeV ν
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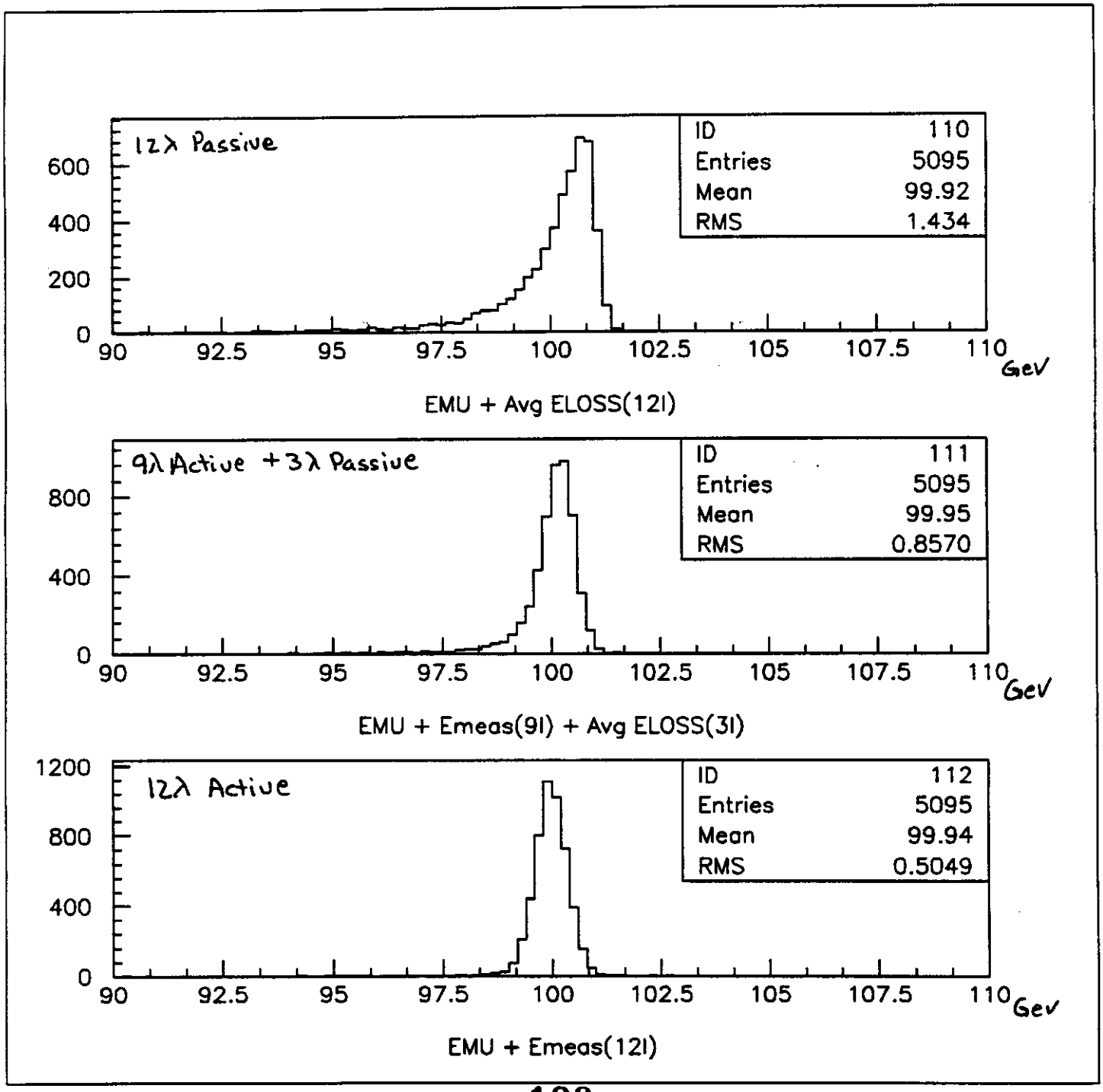
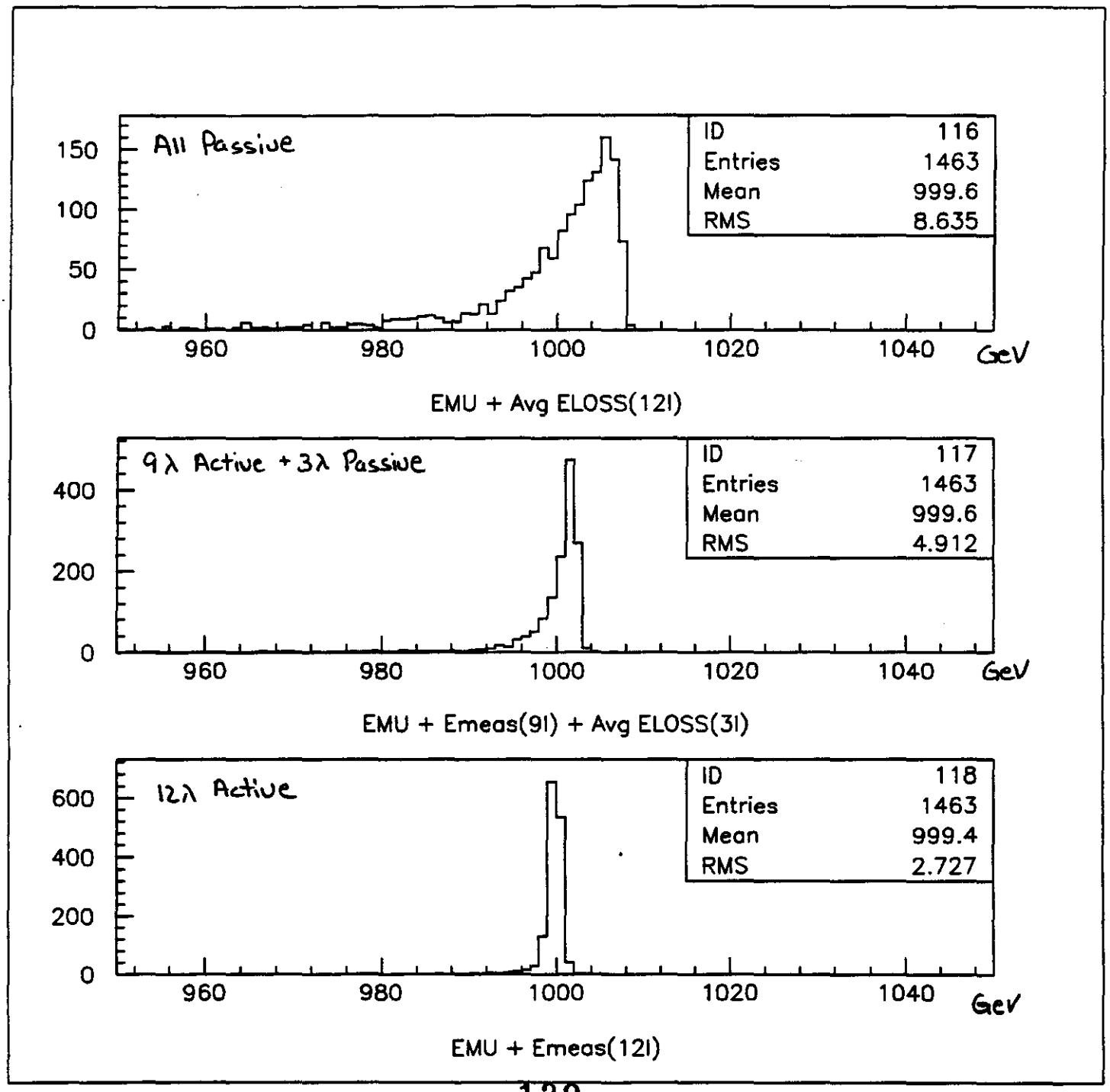


GEANT Simulation of 1TeV ν
through 12λ of Cu/Scint Calorimeter

Reconstruct E_ν assuming perfect measurement of E_ν^{OUT}

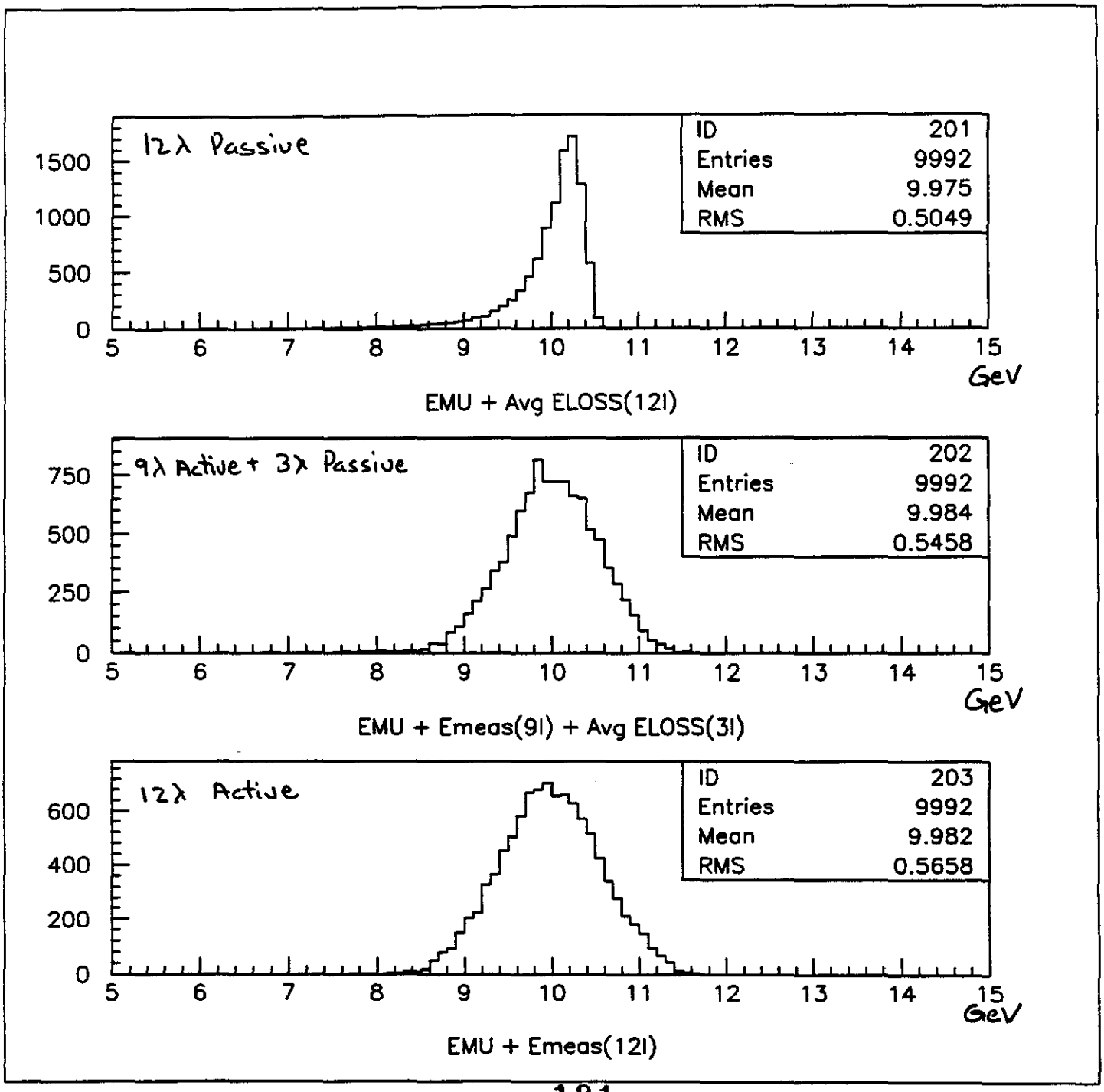
Active Calorimeter resolution: $\frac{\sigma_E}{E} = \frac{20\%}{\sqrt{E}}$



GEANT Simulation of 10GeV ν
through 12λ of Cu/Scint Calorimeter

Reconstruct E_ν assuming perfect measurement of E_ν^{OUT}

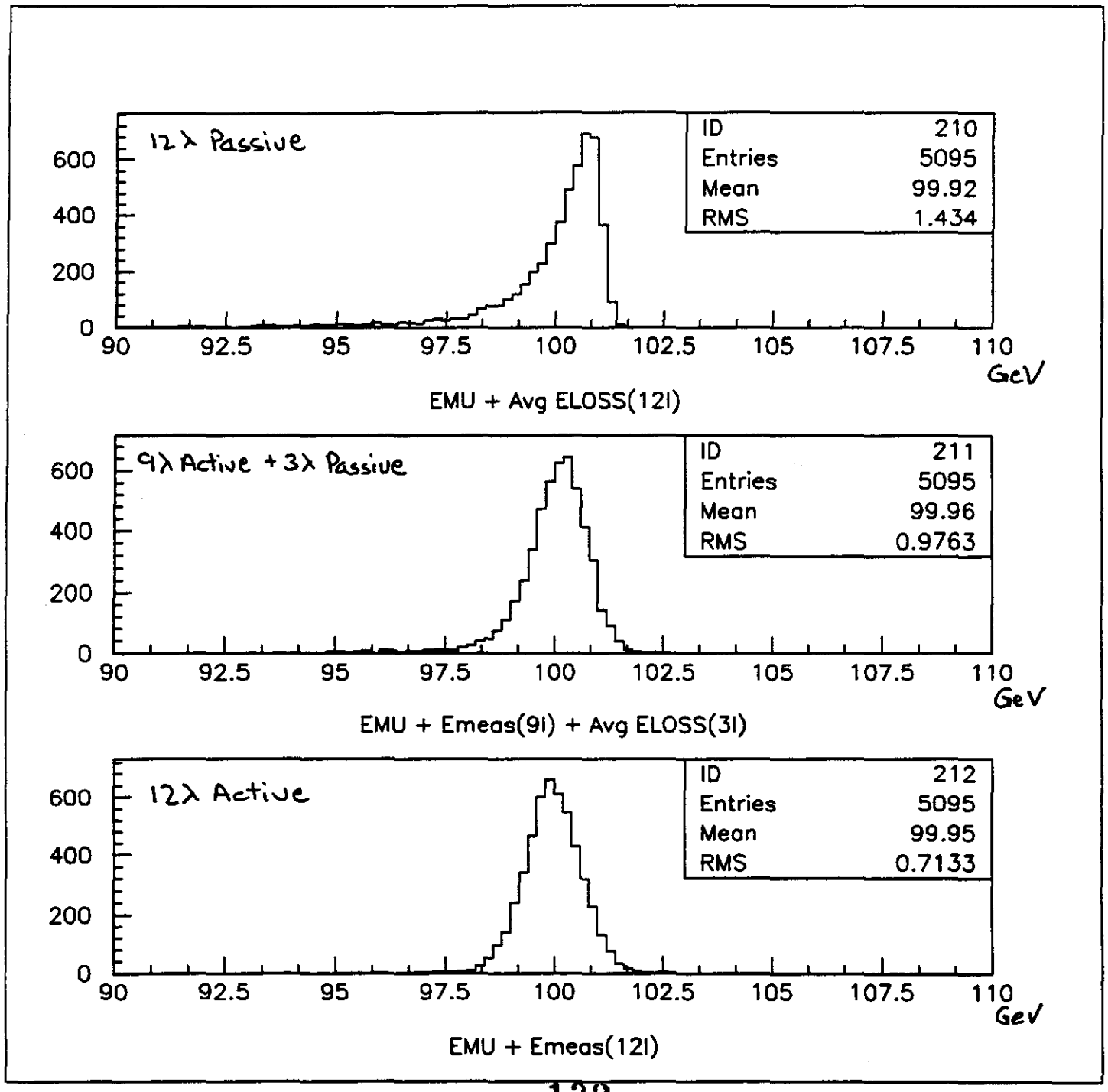
Active Calorimeter resolution: $\frac{\sigma_E}{E} = \frac{35\%}{\sqrt{E}}$



GEANT Simulation of 100 GeV ν
through 12λ of Cu/scint Calorimeter

Reconstruct E_ν assuming perfect measurement of E_ν^{OUT}

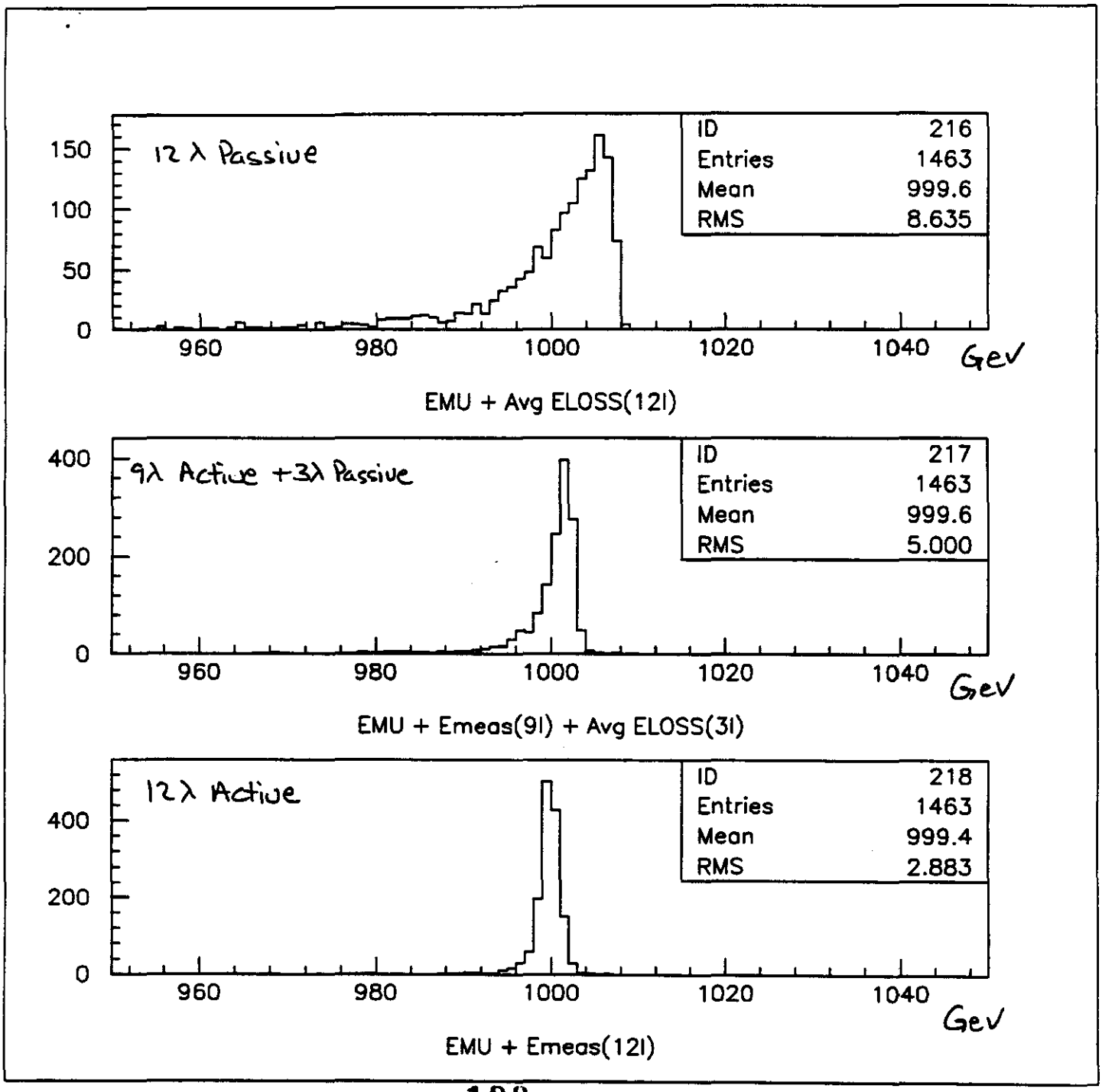
Active Calorimeter resolution: $\frac{\sigma_E}{E} = \frac{35\%}{\sqrt{E}}$.



GEANT Simulation of 1 TeV ν
through 12 λ of Cu/Scint Calorimeter

Reconstruct E_ν assuming perfect measurement of E_ν^{OUT}

Active Calorimeter resolution: $\frac{\sigma_E}{E} = \frac{35\%}{\sqrt{E}}$



CONCLUSION

Assume for Passive Calorimeter we can add in $\langle E_{loss} \rangle$ onl

Try to reconstruct $E_\nu^{INC} = E_\nu^{OUT} + E_{meas}^{CAL} + \langle E_{loss} \rangle^{Passive}$

E_ν^{INC} (GeV)	$\sigma_{E_\nu}/E_\nu^{INC}$ (%)				
	12λ Passive	12λ Active		9λ Active + 3λ Passive	
		$\frac{\sigma_E^{CAL}}{E} = \frac{20\%}{\sqrt{E}}$	$\frac{\sigma_E^{CAL}}{E} = \frac{35\%}{\sqrt{E}}$	$\frac{\sigma_E^{CAL}}{E} = \frac{20\%}{\sqrt{E}}$	$\frac{\sigma_E^{CAL}}{E} = \frac{35\%}{\sqrt{E}}$
10	5.06	3.34	5.67	3.75	5.47
20	3.36	1.85	2.99	2.37	3.16
50	1.52	.83	1.27	1.06	1.36
100	1.44	.51	.71	.86	.98
500	.97	.21	.26	.52	.53
1000	.86	.27	.29	.49	.50

Pattern Resolution Studies

C. Yanagisawa

Effect of Double-hit Resolution on Pattern Recognition @SSCL.

Chiaki Yanagisawa
Stony Brook

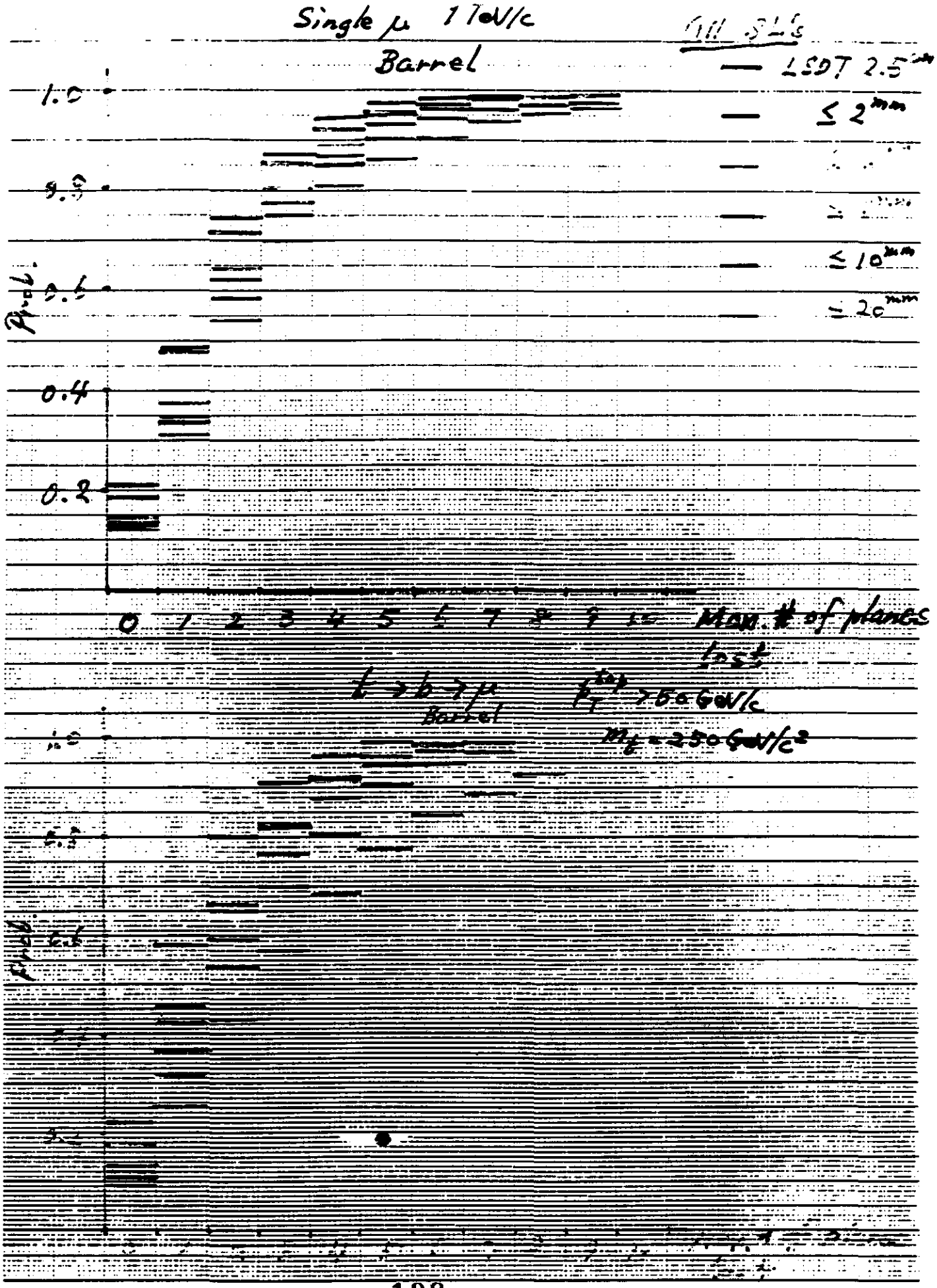
- MC data
  (1) single μ with $p = 1$ TeV/c
  (2) $t \to b \to \mu$ with $p_T^{top} > 50$ GeV/c
  $m_t = 250$ GeV/c^2
- LSDT in Barrel (cell size 2.5 cm)

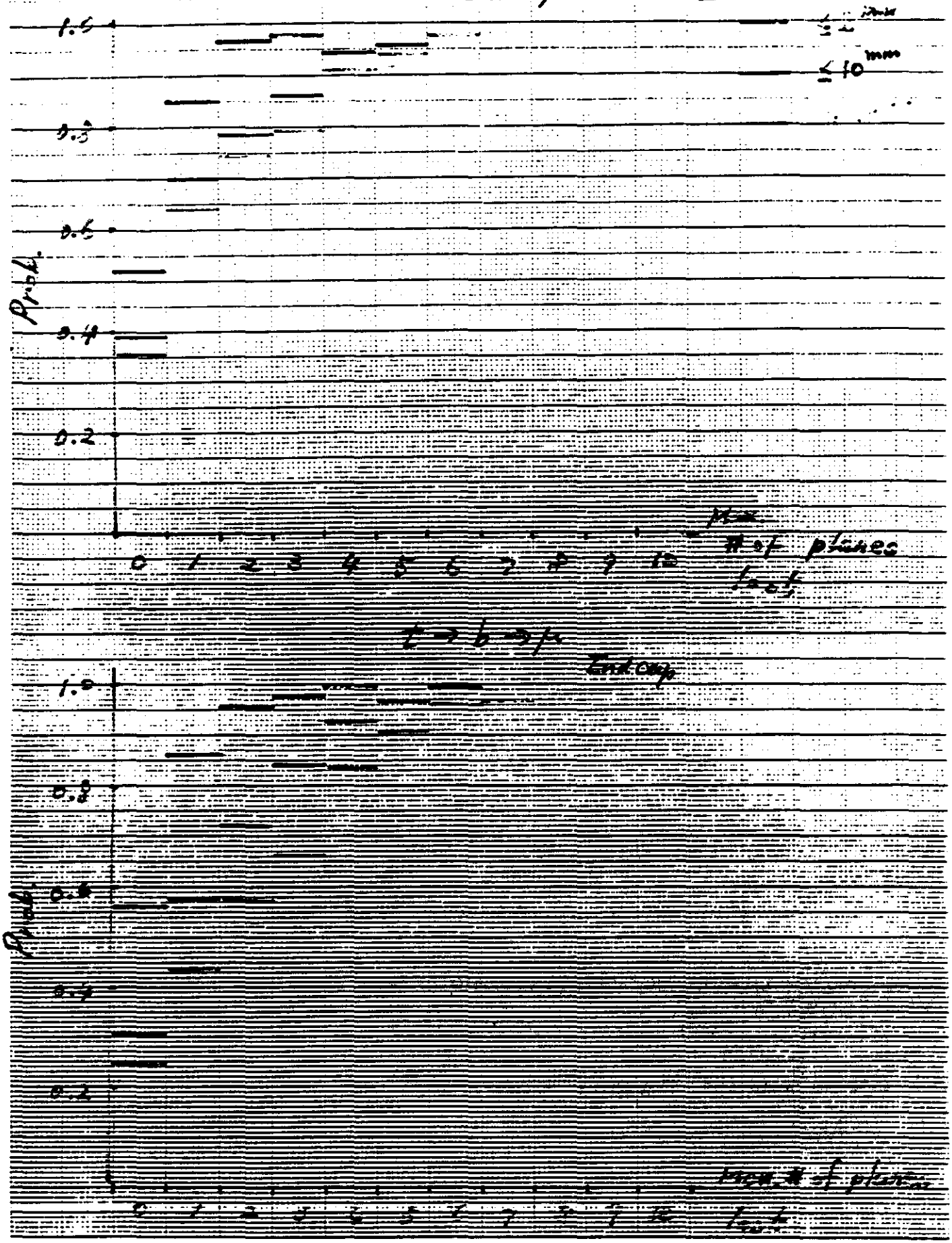
  Take only hit closest to the wire in a cell which has a muon hit.
  If the muon hit is not the closest one, consider the plane to be lost.

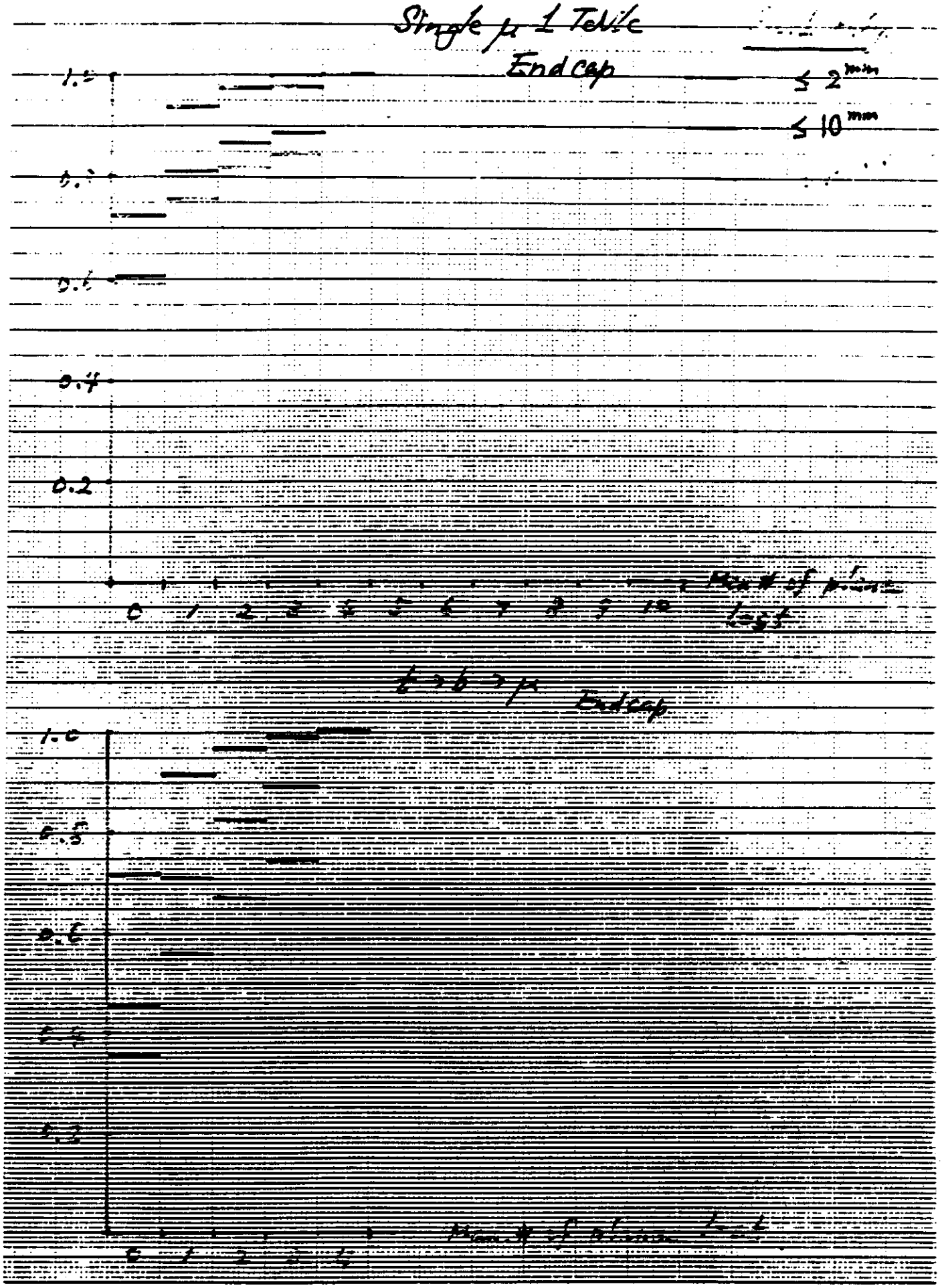
- CSC in Barrel / Endcap

$d \leq 2, 4, 6, 8, 10, 15, 20, 25, 30$ mm
↑ 22.

How often do we lose n-planes?

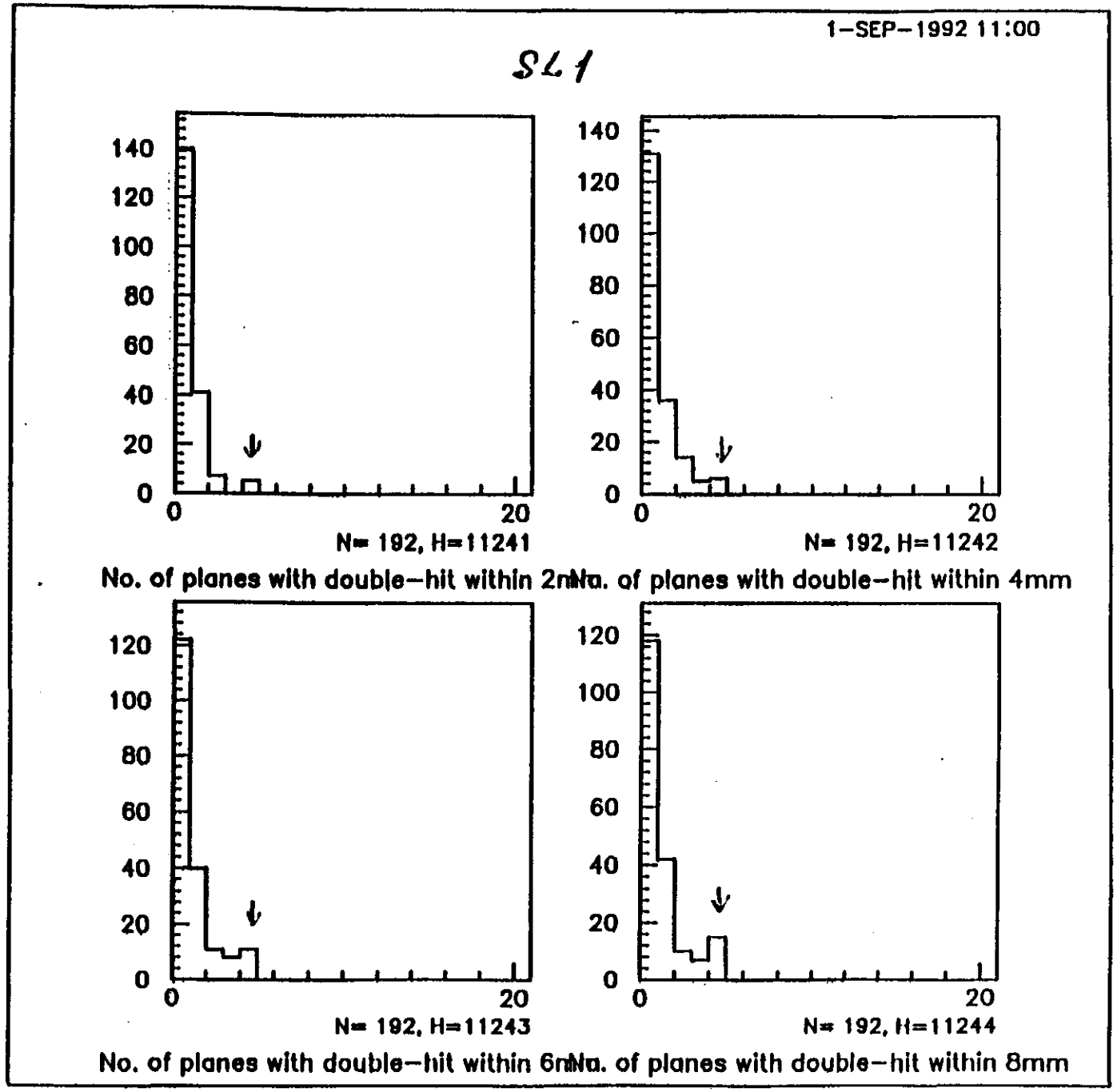

Single μ 1 TeV/c
Barrel
All SL's
LSDT 2.5 mm
≤ 2 mm
≤ 10 mm
≤ 20 mm
Prob.
1.0
0.8
0.6
0.4
0.2
0 1 2 3 4 5 6 7 8 9 10
Max. # of planes lost
t → b → μ
Barrel
p_T^{top} > 50 GeV/c
m_t = 250 GeV/c²
Prob.
1.0
0.8
0.6

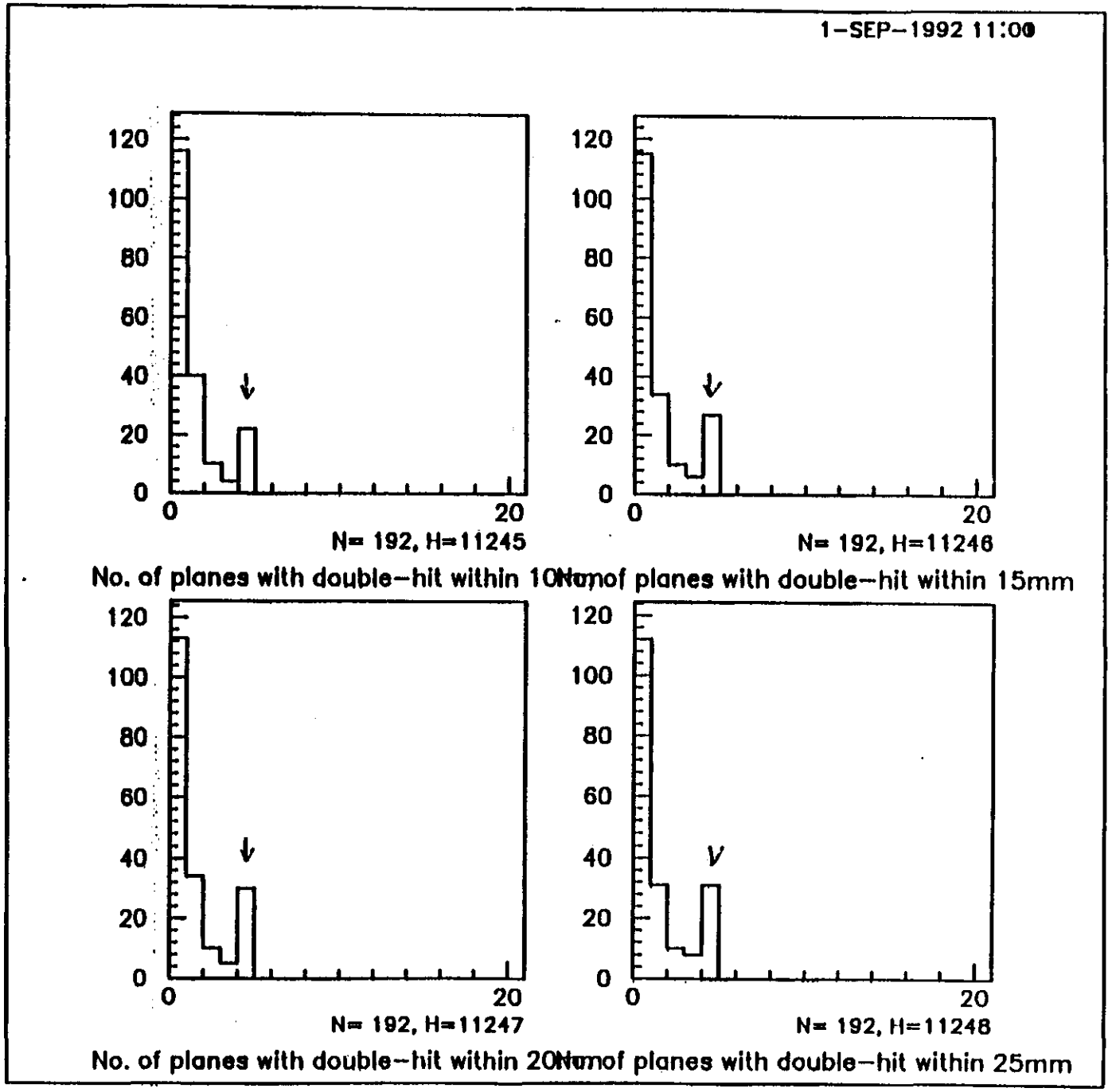

Single μ · TeV/c
Endcap
≤ 10 mm
Prob.
1.0
0.8
0.6
0.4
0.2
0 1 2 3 4 5 6 7 8 9 10
Max. # of planes
Lost
t → b → μ
Endcap
Prob.
1.0
0.8
0.6
0.4
0.2
0 1 2 3 4 5 6 7 8 9 10
Max. # of planes
Lost


Single μ 1 Tevlc
Endcap
≤ 2 mm
≤ 10 mm
0.4
0.2
0 1 2 3 4 5 6 7 8 9 10
Max # of planes
Lost
b → b → μ
Endcap
1.0
0.8
0.6
0 1 2 3 4

46 1510

Single μ 1TeV/c.
CSC
Endcap




1-SEP-1992 11:00
120
100
80
60
40
20
0
0
20
N= 192, H=11245
No. of planes with double-hit within 10mm
N= 192, H=11246
No. of planes with double-hit within 15mm
N= 192, H=11247
No. of planes with double-hit within 20mm
N= 192, H=11248
No. of planes with double-hit within 25mm