GEM TN-92-242

Muon Technology Meeting - Duncanville, Texas

November 19, 1992

Abstract:

Agenda, attendees and presentations of the GEM Muon Technology Meeting held at the Holiday Inn in Duncanville, Texas on November 19, 1992.

GEM Muon Technology Meeting

Duncanville, Texas

November 19, 1992

GEM muon meeting
11/19/92
@SSCL (H. Inn/Duncanville)

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GEM Muon Chamber Meeting - Thursday November 19, 8:30 - 12:30, SSCL
Duncanville Holiday INN (Coffee and Rolls provided!)

General Remarks - Frank Taylor - 5min

List of CSC objectives - Gena Mitselmakher - 5min
List of RDT objectives - Frank Taylor -5min
List of RPC objectives - Craig Wuest - 5min

Status Reports of Tests and Plans to Meet Objectives:

CSCs:
Brookhaven CSCs - Aleksey Vorobyov - 15min
Valery Chernyatin - 15min
Dubna CSC - Yuri Kiryushin -15min
Houston CSC - Kwong Lau- 15min
RD5 tests -5min

RDTs:
MSU chamber - Bob Miller - 15min
Dubna chamber - Sergey Movchan/Andrey Golutvin - 15min
Wire Sag. Calculations - Andrey Korytov -15min
Ideas for Endcaps - Carl Bromberg - 15min
Frank Taylor - 15min

RPCs:
Noise Tests at TTR - Irwin Pless - 15min
LLNL chamber - Craig Wuest - 15min

Organization of Analysis of TTR Tests - 30 min Andrey Golutvin
Andrey Korytov

Discussion of Short Term R&D Plan - Frank Taylor/ Mike Marx - 30 min

Frank Taylor

General Remarks

F.E.T. 11/19/92

GEM Muon R&D Short term

Baseline: CSC everywhere - RDT/RPC backup

- TDR to be submitted 3/15/93

- Chamber R&D to focus on crucial short term items:

BNL Decision: By 1/15/93

(1) CSC prototypes show $\sigma \lesssim 75\mu m$?

(2) Operation of large ($1 \times 2\ m^2$) RPC jitter, noise, slewing, rates ok?

(3) Layout of RDT in endcaps? resolution, rates, trigger?

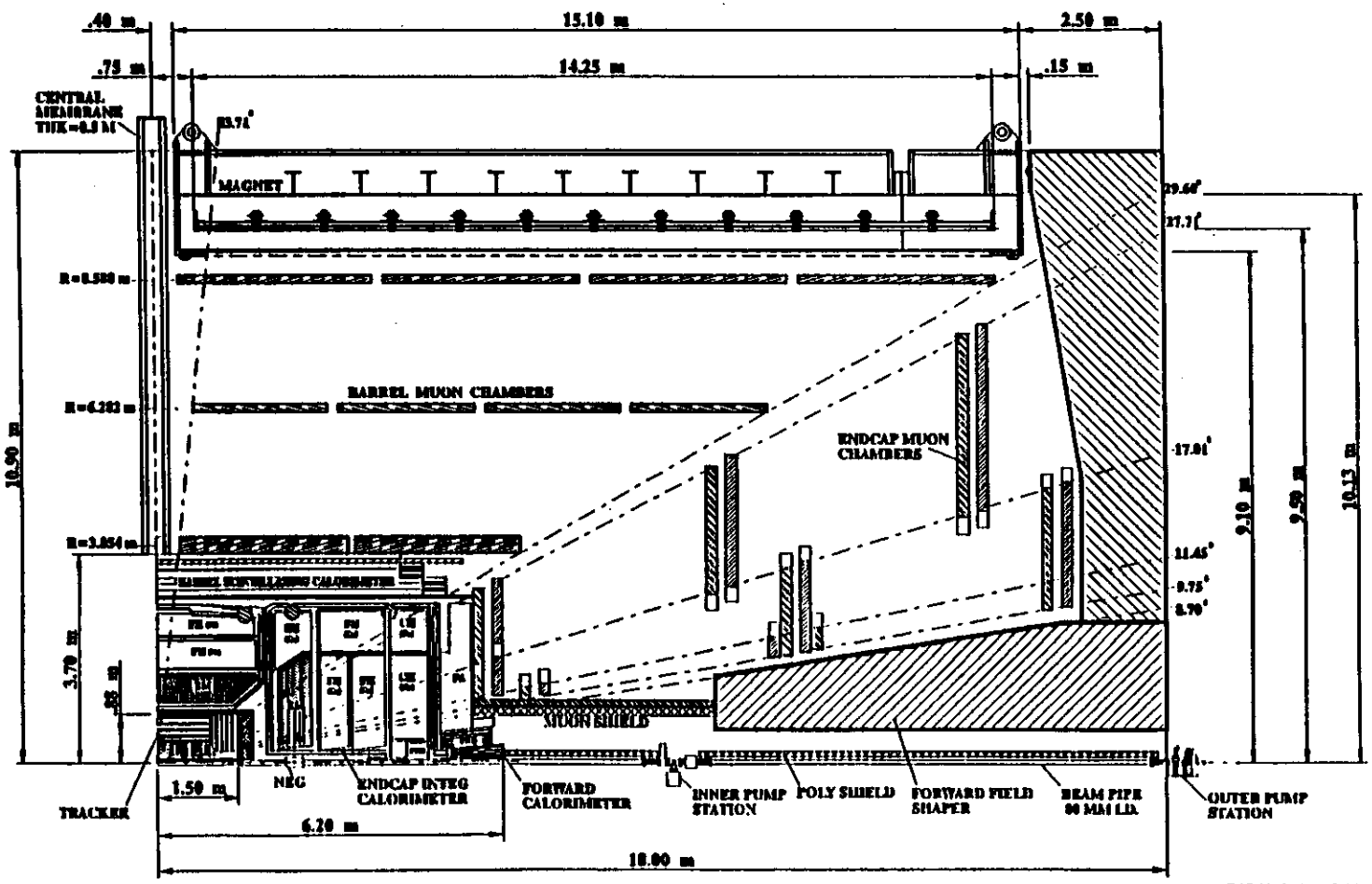
(4) Non flammable gas for RDT?

By 2/15/93

(1) Costing of CSC everywhere incld. electronics

(2) Costing of RDT/RPC everywhere electronics, trigger, etc.

GEM DETECTOR PARAMETERS
BASELINE 2



(PARAlm3 17-NOV-1992)

Engineering Effort Short term:

- Support structures & installation
- Alignment layout & R&D
- Layout of CSC barrel & EndCaps
- Engineering of mechanical design of CSC
  (optimized channel counts
  kinked wires, etc.)
- Layout of RDT/RPC in EndCaps & barrel (update)
- Support of RDT R&D - endcap chamber design - if non rectangular ...
- Costing of CSC option
- Costing of RDT/RPC option

R&D Objectives

TO: Muon Group
FROM: Mike Marx and Frank Taylor
SUBJECT: R&D for Technology Choice and TDR Efforts - Short Term Program
DATE: 11/13/92

(I) Introduction:

Now that we have a more focused program following the BNL meeting decisions, we must concentrate our R&D and Engineering efforts for the next round of the technology decision process and on the writing of the TDR. Given our present state (carry two technology options) we should consider only those long range items (beyond the TDR time-frame) which are essential to start now.

As a boundary condition for this iteration of the FY93 R&D program, we have been asked to make no commitments in either personnel or funding for any item beyond the TDR which would close any option (new personnel) for a later phase.

We suggest that the R&D effort from now until March 1993 be organized along the following lines.

* Chamber R&D:

This effort will focus on those items crucial to evaluate the technology choices. There are 5 subtasks in this high priority category involving the TTR measurements, and R&D on CSC, RDT, RPC, and electronics conceptual design and costing.

* TDR Work:

This task is directed towards writing a defensible TDR which needs the support of detailed calculations and measurements. That involves developing our base-line and backup technologies, and includes the completion of the design of the chamber support structure, design of the alignment system, layout of chambers, resolutions, hadron punch-through and neutron rates, trigger concept and simulation, and hit-level Monte Carlo simulation.

The TDR writing assignments and rough outline (more required) have been given in our 11/11/92 memo and will not be repeated here.

* Essential Long Term R&D:

One essential long-term project is to develop plans for a prototype sector to be furnished with chambers, attachment fixtures, and alignment hardware. Layout of a prototype factory is another item which should be started - although the details should await the final technology choice and the completion of the "industrialization" process.

(II) Specific R&D Tasks:

(1) Chamber R&D Crucial to the Technology Decision Process
(Note that the list of participants is to be filled out later.)

Task 1.1: TTR Measurements

Task Coordinators: Andrei Golutvin and Andrei Korytov

Contributors: to be completed

Deliverables: (i) Operate the TTR to determine the single layer resolutions of the CSC and RDT prototypes.

(ii) Investigate the simultaneous operation of the RPC with the other two technologies, especially the RDTs which may need the RPCs for a trigger. Of interest is the noise sensitivity of the CSC chambers to the RPC noise - a relevant issue if we decide to build a hybrid muon system.

The intent of having a common analysis group for all technology options is that cross comparisions can be made and a uniform set of standards applied to all the technology options.

Task 1.2: CSC R&D

Task Coordinator: Gena Mitselmakher

Contributors: TBC

Deliverables: (i) Measurement of the single layer resolution of the CSC chambers in the TTR and RD5 tests. To meet the baseline resolutions this must be < 75 um.

(0.5m×0.5m), Duke CSC (1.5m×1.2m), UH CSC (1m×0.5m), RD5(?), BNL (1×1.?)(?)

(ii) Invesitgate the kink wire design for the EC chamber L-angle compensation. Work out details of the design in terms of what are the optimal angles as a function of position, mechanical tolerances, mass production, etc. PNPI+BNL

Dec 10 decision

(iii) Study the production of large cathode planes. Are the precision requirements attainable (strip separtion, flatness, and stability)

(iv) Work out optimal configuration of chambers in the barrel and endcaps. Is there a way to reduce the channel count while maintaining performance?

UH, PNPI, (v) Provide experimental evidence that the beam crossing can be tagged with high efficiency.

(vi) Investigate noise susceptability at the TTR. How does the single layer resolution depend on the noise pedestal.

Task 1.3: RDT R&D Short term

Task Coordinator: Frank Taylor

Contributors: TBC

Deliverables: (i) Find a nonflammable gas with which the baseline resolution (<100 um single layer) and timing are achieved.

(ii) Provide a crediable design for chambers in the endcaps in terms of momentum resolution, (triggering), and

operation in the charge particle and neutron backgrounds.

(iii) Show that mechanical aspects of the chamber design, such as wire sag, concentricity of tubes, inside tube wall surface effects, overall error budget are under control.

(iv) Make a determination that the stand-alone trigger concept is viable (costs, complexity, performance) in both the barrel and endcaps.

(v) Perform a system optimization, deciding tube diameters, number of chambers and alignment paths, etc.

(vi) Show by measurements that the RDT can be operated simultaneously with the RPCs.

Task 1.4: RPC R&D:

Task Coordinator: Craig Wuest

Contributors: TBC

Deliverables: (i) Determine a nonflammable gas mixture.

(ii) Construct a ~~1m x 1m~~ 1.2 x 2.4 chamber with low resistivity plastic and show that the noise/area is under control.

( ) Measure n efficiency for RPC plastic

(iii) Show that the RPC can be operated at high rates while maintaining the time resolution.

( ) False trigger calculation for n bkgd.

(iv) Contribute to the compatability tests with the RDT, and CSC's

(v) RPC Design in endcap-geometry

Task 1.5: Electronics Design (in collaboration with GEM Electronics Group)

Task Coordinators: Dan Marlow and Mike Shaevitz

Contributors: TBC

Deliverables: (i) Conceptual design of CSC readout and trigger electronics designs.

(ii) Conceptual design of the RDT readout electronics

(iii) Conception design of the RDT stand-alone trigger.

(iv) Conceptual design of the RPC readout and trigger.

(v) Uniform costing of all technology options.

(2) Essential Mechanical Engineering:

These tasks are to provide engineering support for the chamber designs, deployment of chambers in the support structure, the design of the support structure, design and deployment of the alignment system, etc. This work should be coordinated with the essential chamber R&D and the TDR writing. These tasks are outlined in the FY93 R&D Plan, rough draft distributed 10/16/92.

For today

- Review of short term chamber R&D
- list of objectives/technology option
- Outline strategy of how & who to do work
- Want CSC & RDT/RPC to work as a team

- Discussion of R&D Fy93 Plan
  - distribution
  - home work for everyone

Alexei Vorobyov

PNPI - CSC

PNPI

in CSCs activity

50K$ + 50K$

Prototypes construction and tests

0.2 × 0.2 m2 wire strips.
1.0 × 1.0 m2 wire strips
4 layers 0.5 × 0.5 m2 honeycomb (BNL)

FY 92

Plans for FY 93

New 4 layers 0.5 × 0.5 m2 honeycomb (Gatchina)
- strip configuration optimization
- tests in 1 Gev/c proton beam
- tests in neutron B.G.
- tests at CERN (?)

0K$ including new one

Several 0.2 · 0.2 m2 honeycomb (Gatch.)
- wide strips (no floating)
- inclined anode wires
- tests in proton beam
- Neutrons
- Magnetic field

t. Small ring endcap prototype

(r, φ) - coord. } to be chosen before Jan. 93
(X, Y) - coord. }

50K$

(2) Drifts and L.A. 5K$

50% CO_2 + 30% Ar + 20% CF_4 } studied
— " — 30% Xe — " — }

(Xe) — X-ray calibr. and align.
1.6 times bigger signal.

Plans for FY93

Other mixtures.

3) CSCs in magnetic fields (10K$)

a) α-recoil method
b) Sup. Cond. Solenoid
c) Cosmic rays.

} FY93

4) X-rays test station (40K$)

* X-ray tube
* monochromator
* moving table 1×1 m²
* Electronics
* tests

} FY93

Project for test station at SSCL (collab with LNL). – FY93

(5) Anode front-end electronics (2U N/D)

* Anode preamps (Russian comp).
  (2 options are designed and 1 is produced)
* Anode preamps
  (in collab with BNL) (US comp.)

(6) IC test facility (5K8)

* Project for test fac.
* Final stage of fabrication IC.
  (hybrid techn. facility).

7) CSC - factory (85 K$)

Existing facility - 400 m2
(26 engineers and techn.).

New facility - 1100 m2

Total staff ≈ 50 people

Production rate

all CSCs for End caps
for 3 years

Option: the biggest chambers
(3.5 meters) are produced in Dubna
or China.

Budjeet request for FY 93

200 K$ + 10 Mrubles
+50 K$ if (T,q) prototype to be done

PNPI Plans for 93 (people)

SSL	tests	4 person. (engineers) 2 physicists.
BNL	1 × 2 m2	
Gatchina		~ 30 phys + eng. + tech.

Yu. Kiryushin

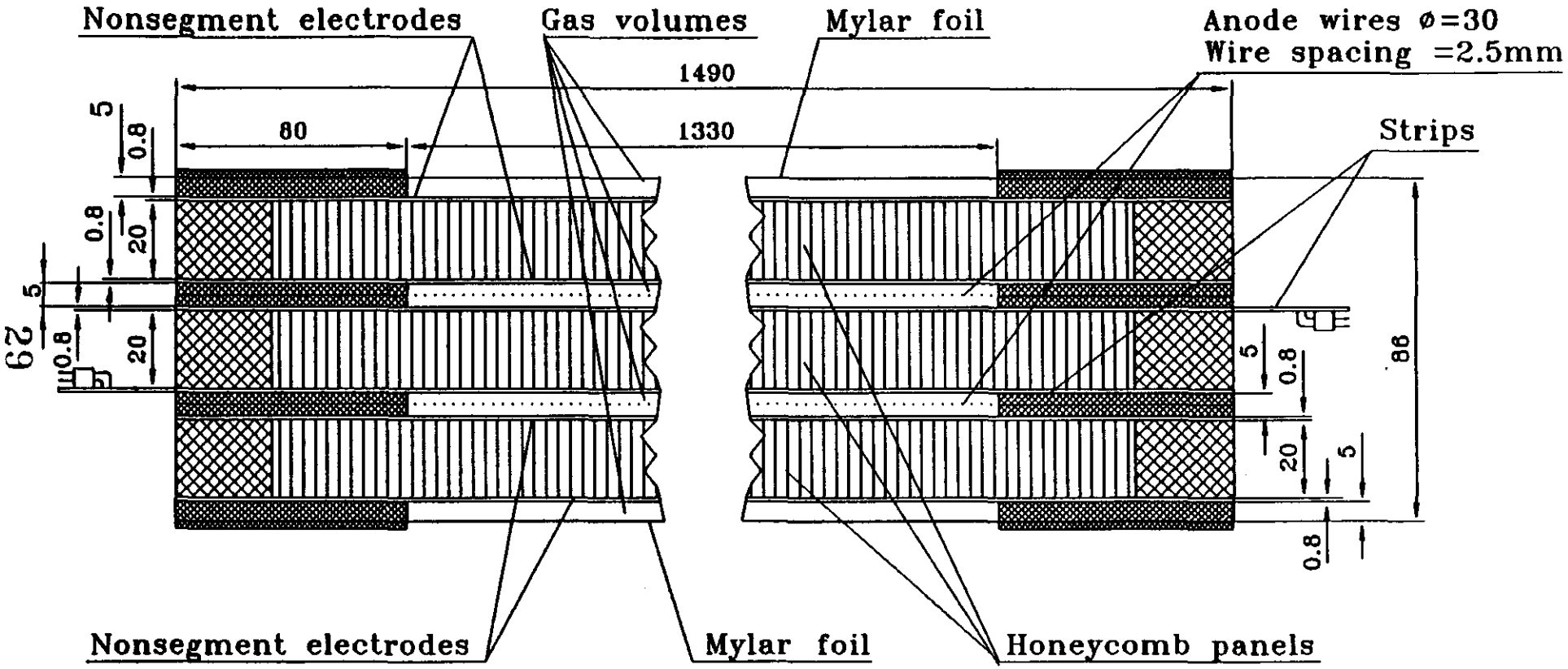
Dubna - BNL

CSC

DUBNA CSC-test Status

Yu. Kiryushin
Dubna - BNL

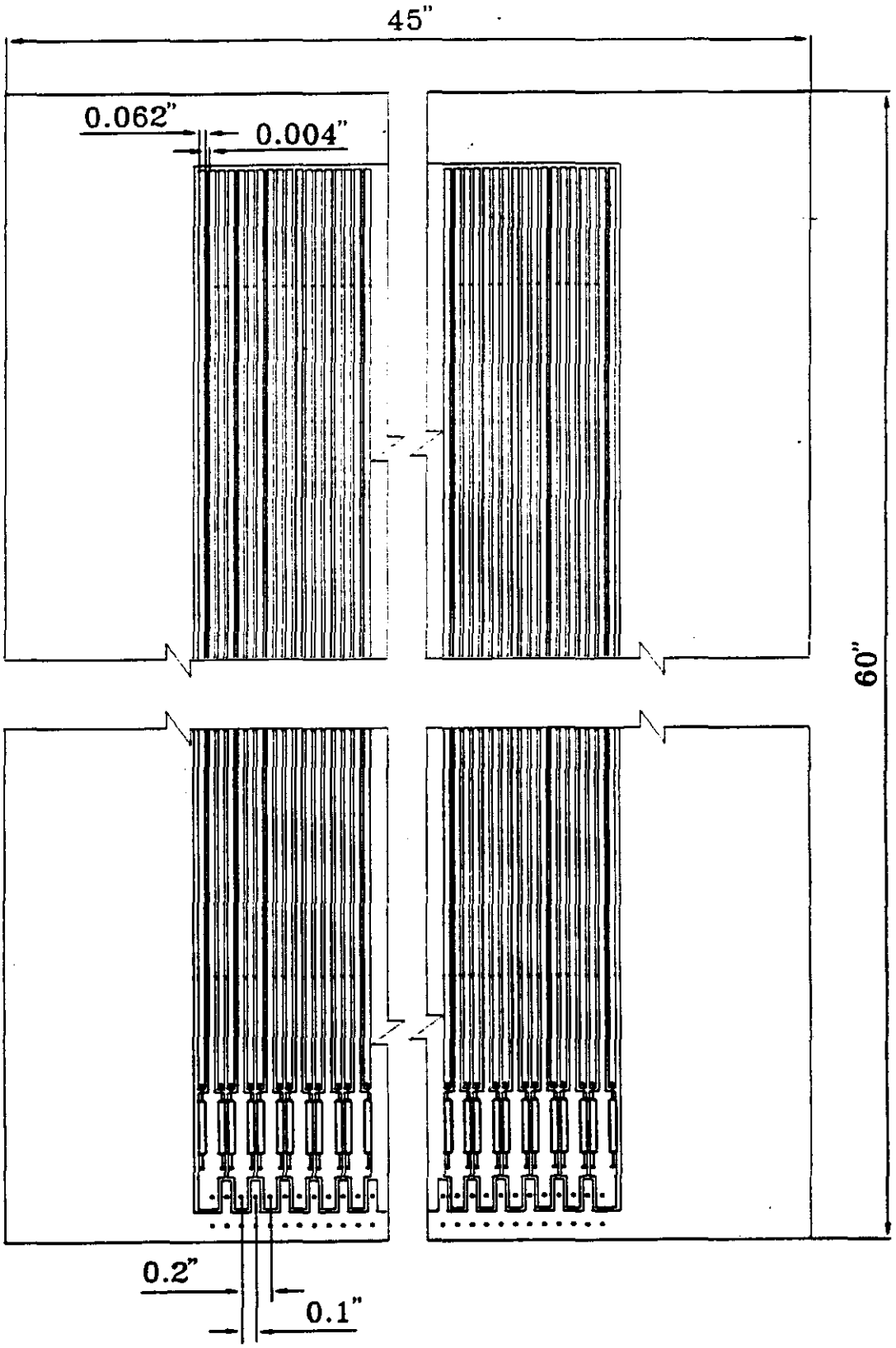
DUBNA CSC PROTOTYPE



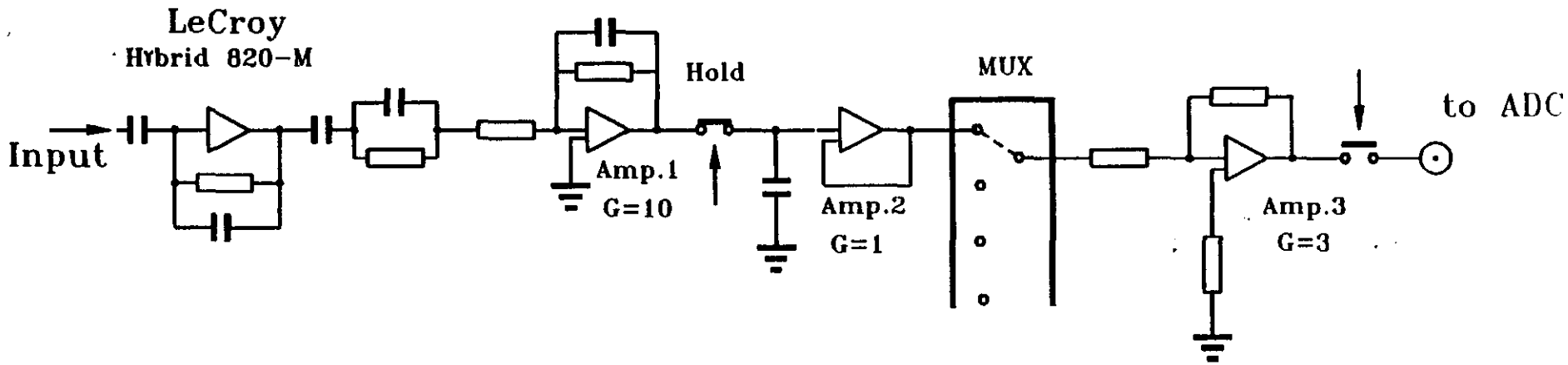
Cross-section of MWPC perpendicular to the wires

(All dimensions in mm)

STRIP CATHODE



STRIP READOUT ELECTRONICS



Noise – ENC 2500± 500 r.m.s. electrons for 100 pF

Peaking time – 2 μs

Readout time ~ 1.5 μs/channel

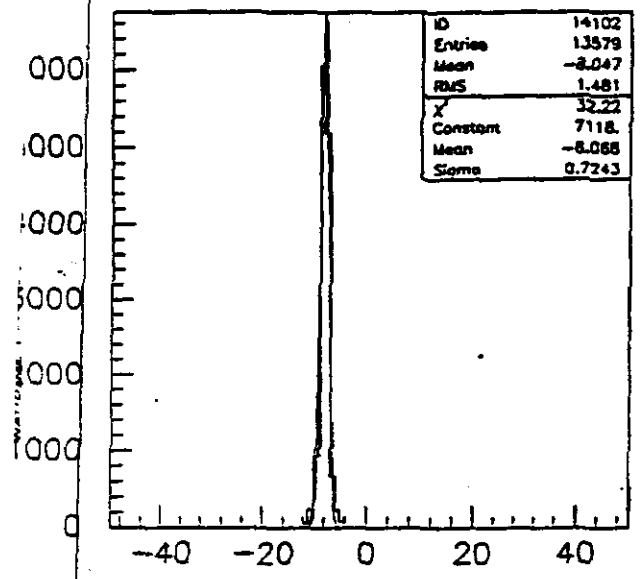
The most work has been done with electronics:

1. Gain ~ 10 V/pc at the input of ADC
2. Range of ADC - 0-640m Corresponds to 0-512
3. Increse read-out time now is ~ 3 μks/ch
4. Check the pedestals and noises

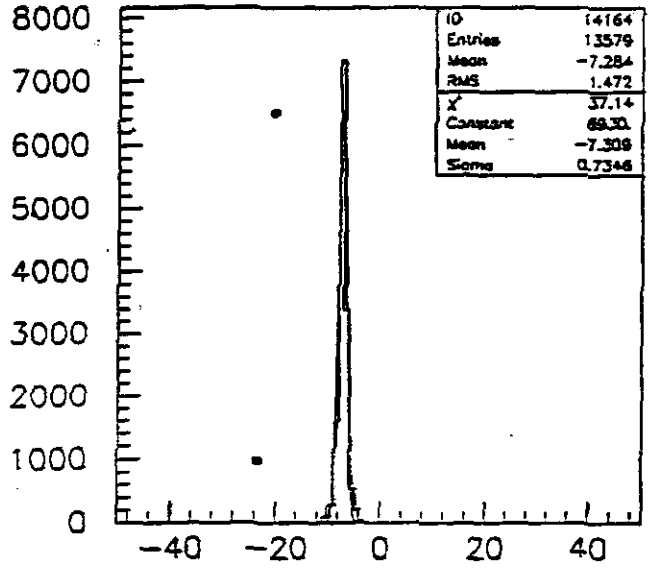
$$ENC = 1 \cdot \frac{640\ mV}{512} \cdot \frac{10^{-12}}{10\ V} \Big/ 1.6 \cdot 10^{-19} =$$

$$\approx 1000 e^- !$$

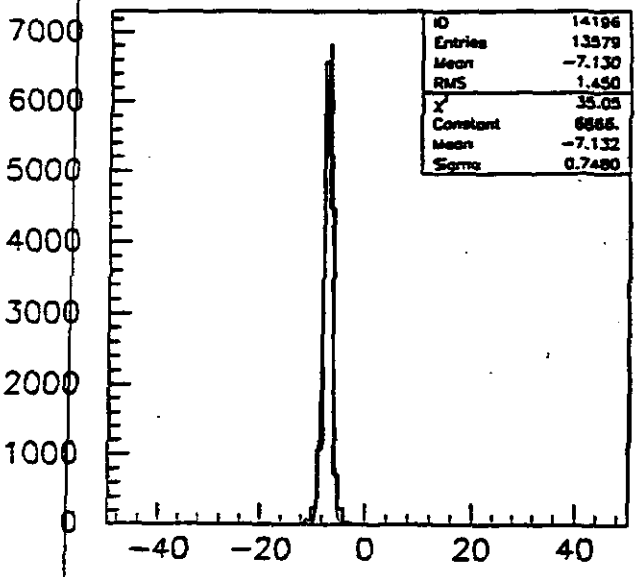
DUBNA CSC Pedestals in RUN 0066 11-10-92



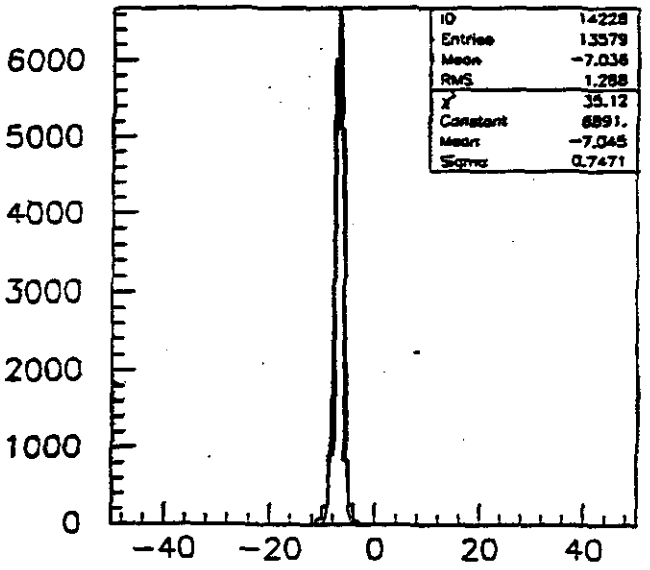
DUBNA CSC ADC Channel 2



DUBNA CSC ADC Channel 64



DUBNA CSC ADC Channel 96



DUBNA CSC ADC Channel 128

5. 33 Hybrids HQV 820-M arrived a 3 days ago

6. Found that some HQV are very sensitive

7. Put the good groundin on the chamber.

Plans:

1. Finish installation of HQ

2. Calibration of each strip readout channel

3. Move the chamber to TTR (next wee to make measument of space resolution

Our second activity is to design a full-scale CSC prototype for barrel.
CSC prototype for EC

1. Dimensions - 3.4 x 0.96 m^2
2. Number of gaps - 4
3. Fine stripredout - 4 planes
4. Corse strip. - 4 planes
5. wire spacing - 2.5 mm

Gap - ?

Can we increse the gap to 5 mm?

ITEP at Moscow has a running V. Tchernatin-programm for CSC-simulation.

The calculations show that

for: gap - 5 mm
strip redout pitch - 8 mm
strip width - 7,6 mm
magnetic field B(z) = 0.8 Tl
wire spacing - 2.5 mm

LA — 8°

Gas — 50% CO_2 + 50% CF_4

σ_{noise} — 2000 e

Gas gain — $5 \cdot 10^{4}$

$\sigma_{av.} = 66$ мкм.

Now we are going to perform calculations more acurately.

· RDT - PROTOTYPE with the tubes of 25 мм in diameter.

Kwong Lau

CSC

UH CSC

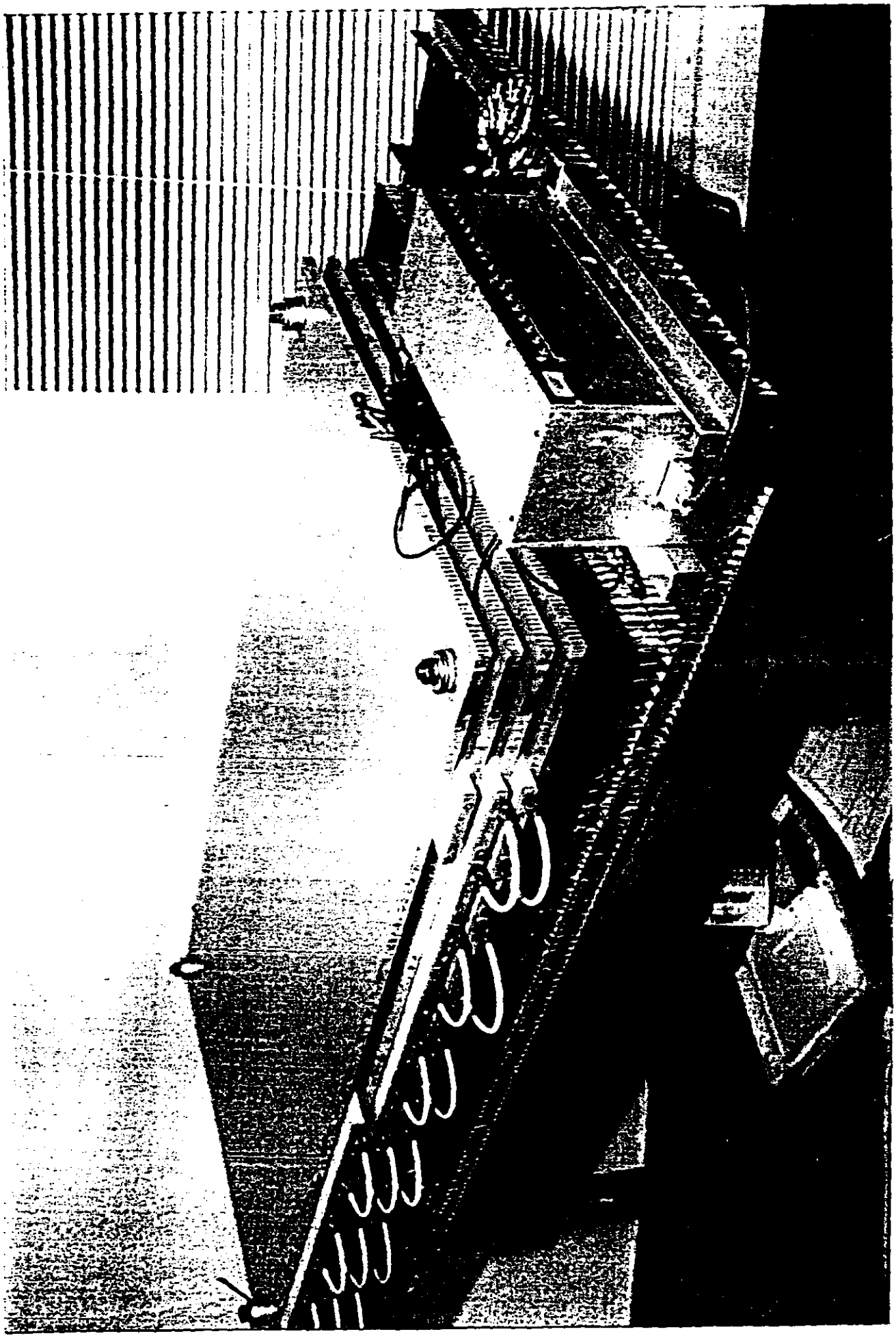
Status Report

UH / SSCL / Dubna

Kwong Lau

GEM μ meeting

Nov 19, 1992 (SSCL).



UH CSC Prototype

- 3 layers of 1.0 m (long) x 0.5 m precision strips (pitch = 5.0 mm = 4 mm Cu + 1 mm gap)
- 3 layers (12 chambers per layer) of 66-cm Iarocci-type carbon-coated (4 kΩ per square) profiles with 45 μm gold-plated tungsten wires
- standard (75/25 Isobutane-argon) gas mixture at 3.1 kV (proportional mode)
- 10 (top), 9 (middle), and 8 (bottom) strips at center from the three layers were connected to Dubna design low-noise preamps (gain $\simeq$ 1000)
- preamp outputs are routed via 53-m RG174 coaxial cables to Lecroy 2249W ADCs with an integration time of 500 ns
- trigger on 2 top scintillators and all bottom scintillators

Key Milestones

- 9/15 Prototype delivered to SSCL
- 10/15 Prototype installed in TTR
- 10/23 First data run (30,000 triggers)
- 11/19 Preliminary results

Analysis Technique

- select events with at least 1 strip with $\geq$ 100 ADC counts and $\leq$ 1980 ADC counts
- apply gain ($\pm$ 20 %) and pedestal (20-30 ADC counts) corrections
- locate peak channel in each layer and require peak to be at least 1 or 2 channels from edge of instrumented strips
- determine c.o.g. ($z_{c.o.g.}$) of the hit for each layer by using 3 strips ($z^{(3)}$) and 4 strips ($z^{(4)}$)

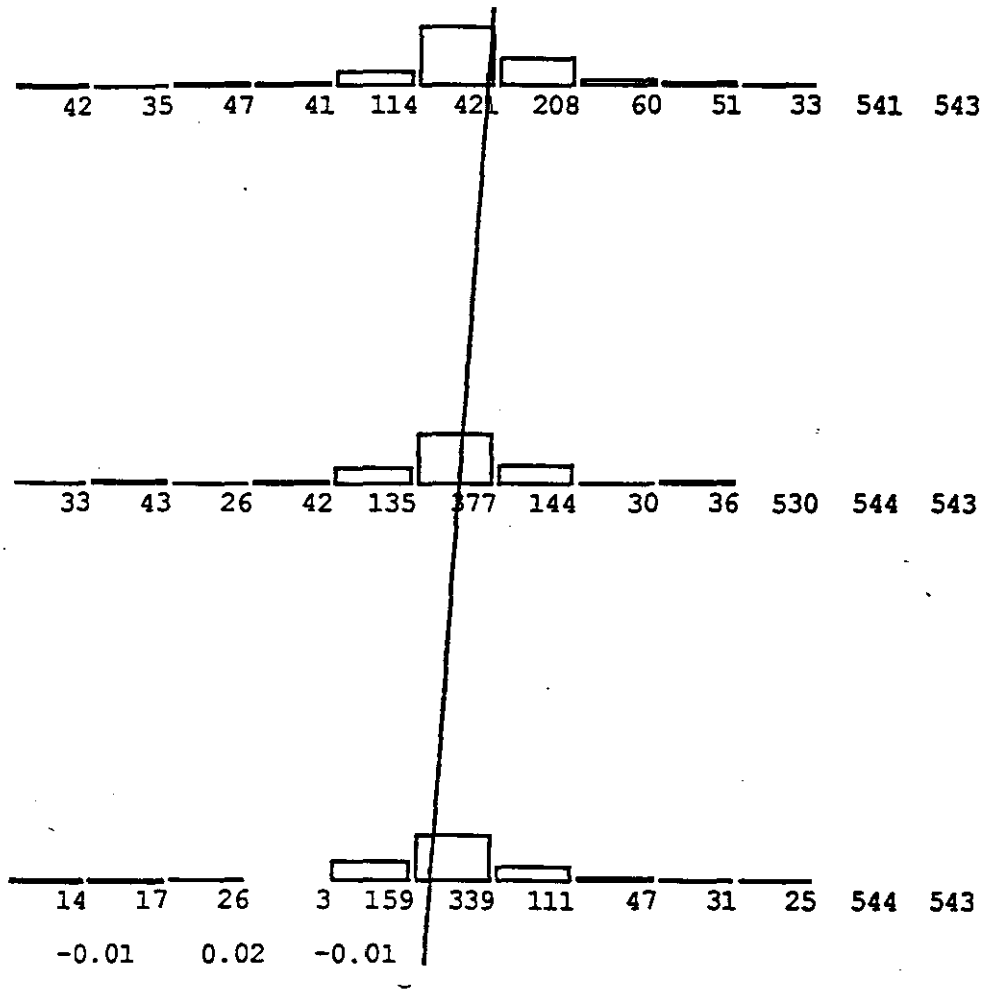
$$z_{c.o.g.} = \frac{z^{(3)}}{1 + \frac{2}{w}(z^{(3)} - z^{(4)})}$$

- apply systematic correction

$$\Delta z = 80\mu m \times sin(\frac{(w/2 - z)\pi}{w/2})$$

- fit corrected points to a straight line
- determine resolution per plane from residuals

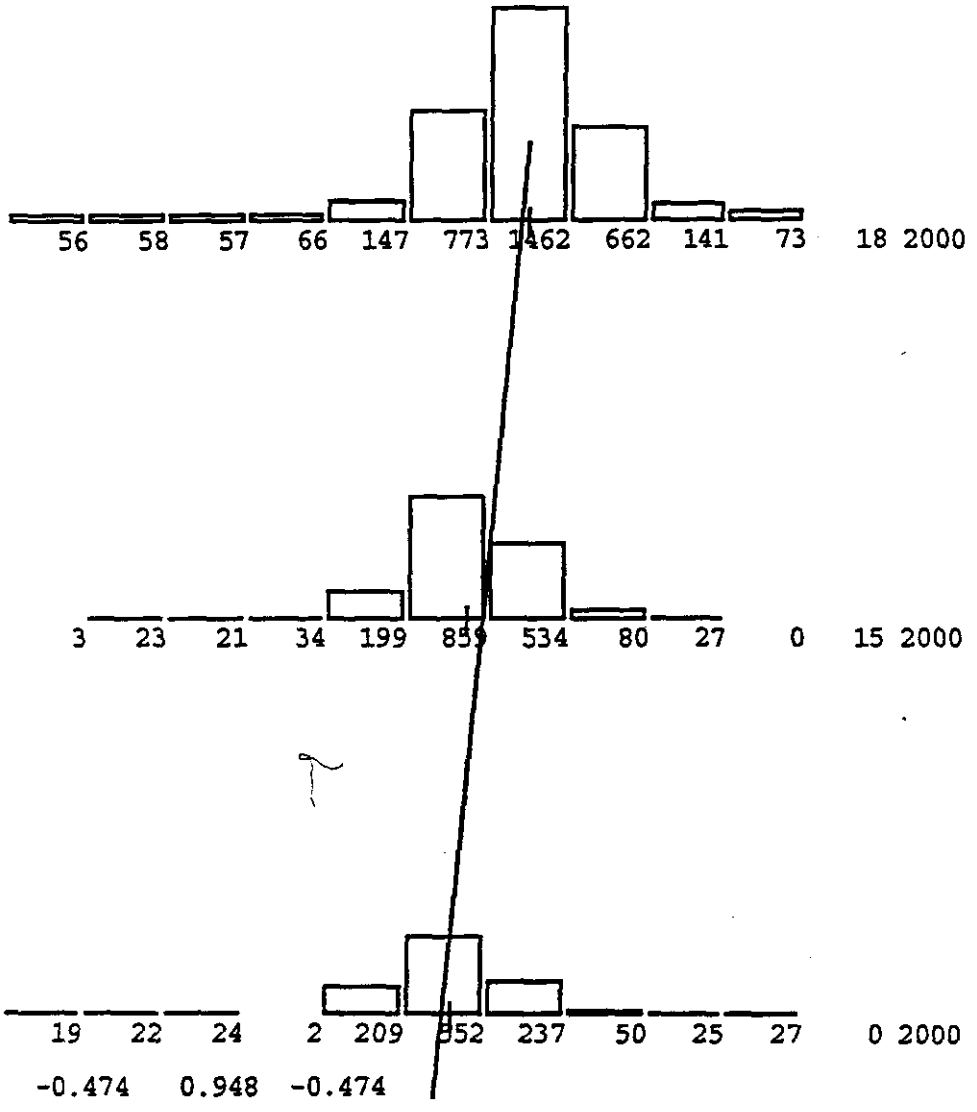
Run#: 666 Events on File: 45442 groups on file: 2
Event#: 4200 Fri, Oct 23, 1992 17:45

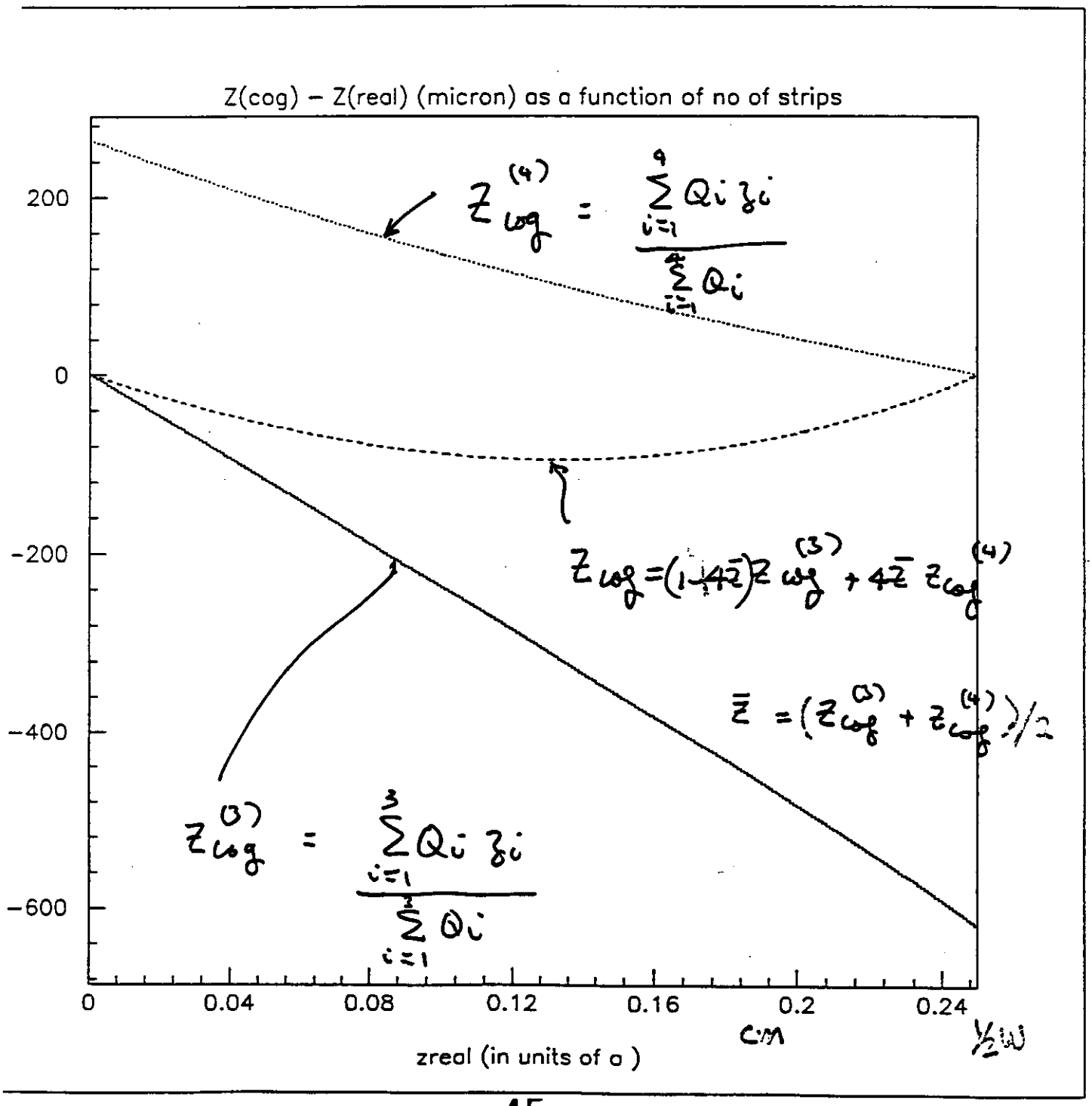


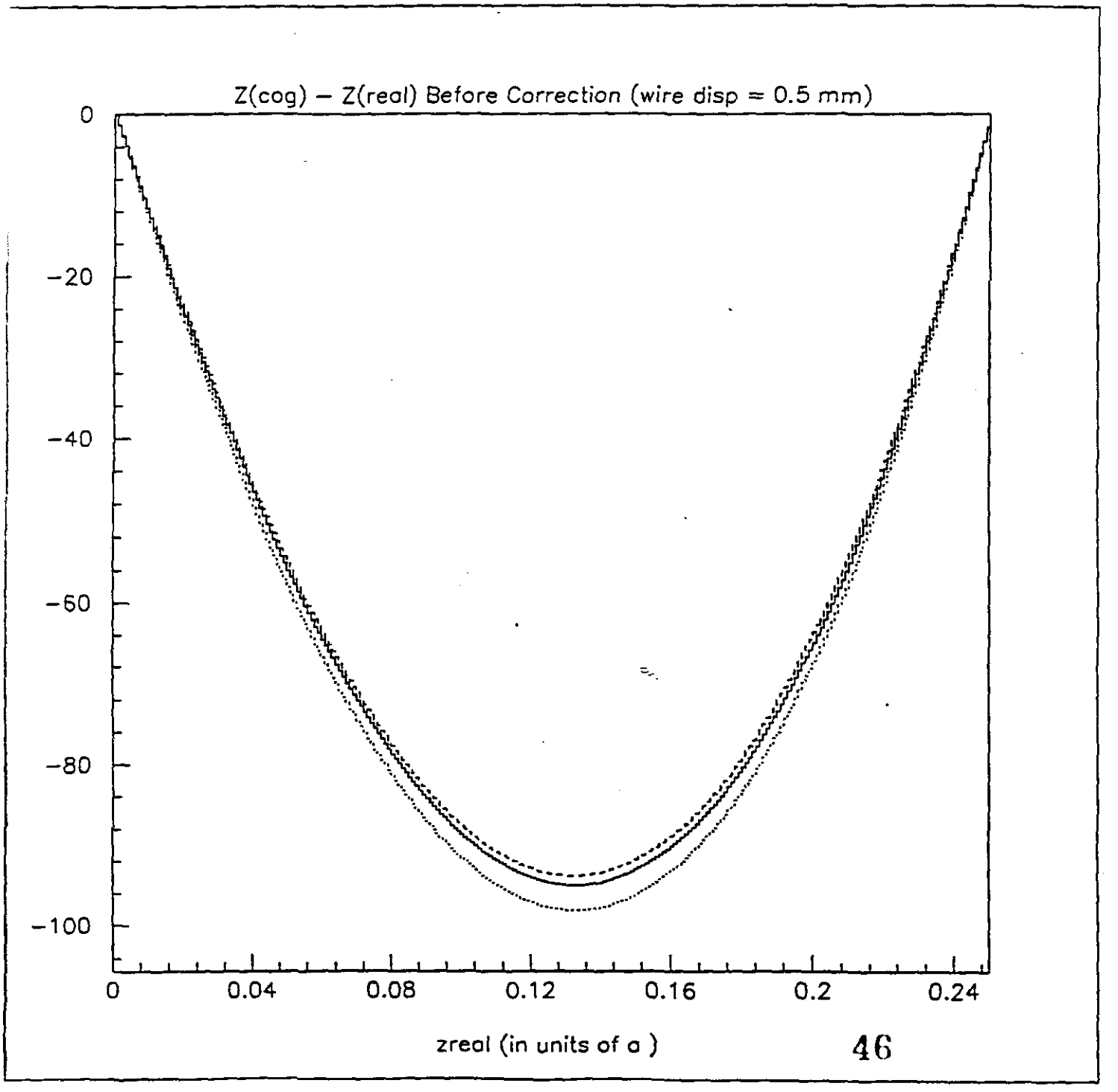
$$R_1 = R_3 = -\tfrac{1}{2}R_2$$

$$\sigma = \sqrt{6}\, R_1$$

Run#: 666 Events on File: 49127 groups on file: 2
Event#: 6311 Fri, Oct 23, 1992 17:47

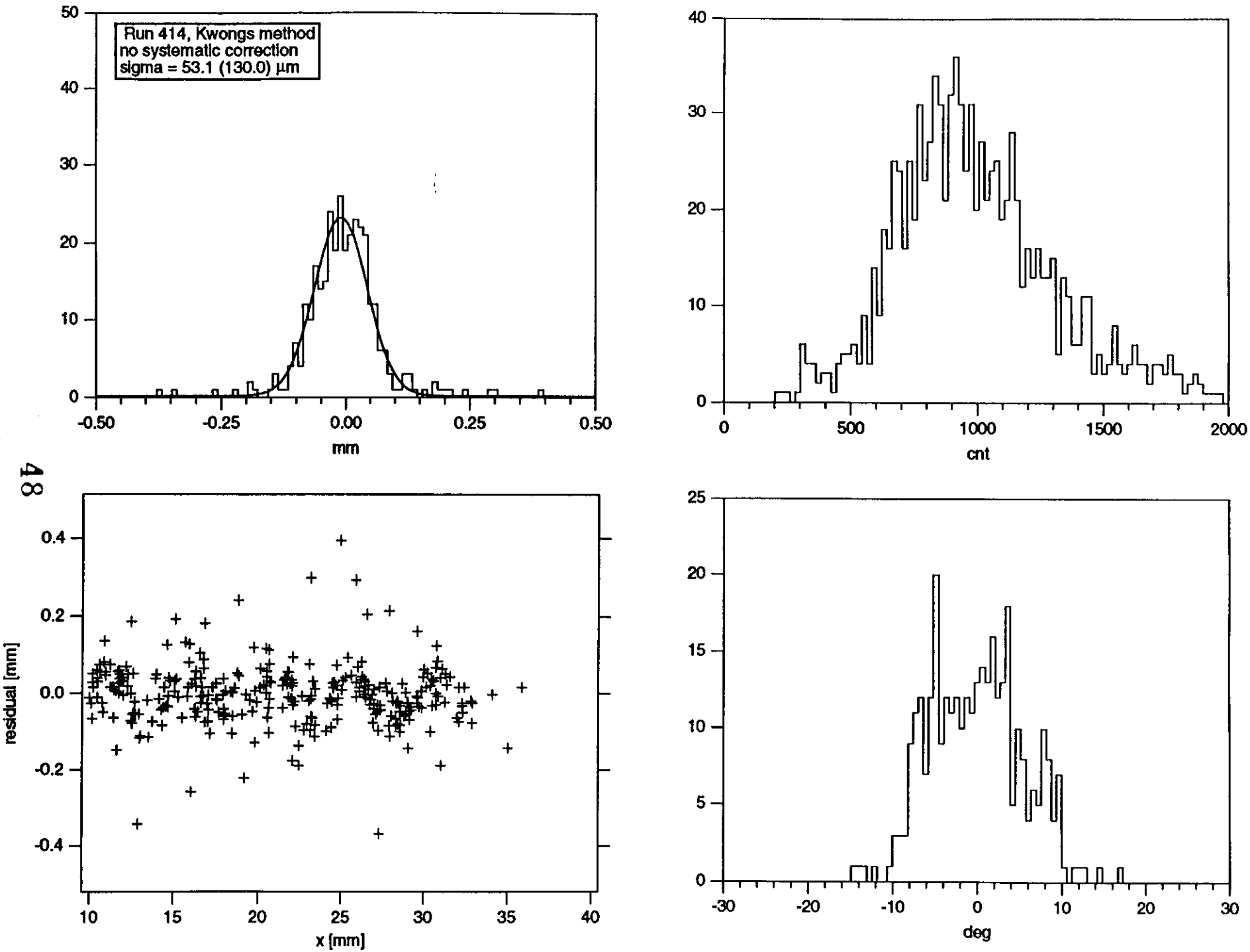


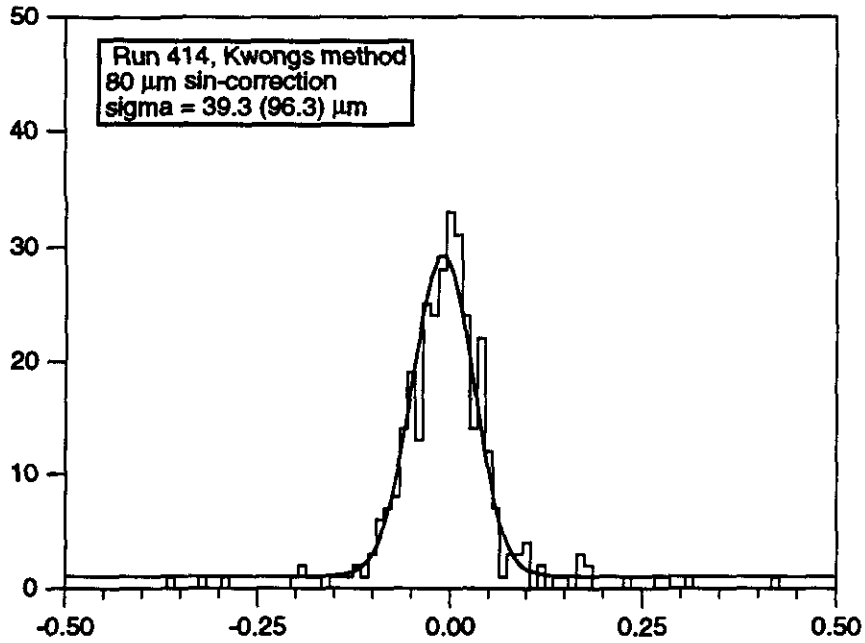

Z(cog) – Z(real) (micron) as a function of no of strips
200
0
-200
-400
-600
0
0.04
0.08
0.12
0.16
0.2
0.24
zreal (in units of a)
$Z_{cog}^{(4)} = \frac{\sum_{i=1}^{4} Q_i z_i}{\sum_{i=1}^{4} Q_i}$
$Z_{cog} = (1-4\bar{z}) Z_{cog}^{(3)} + 4\bar{z}\, Z_{cog}^{(4)}$
$\bar{z} = (Z_{cog}^{(3)} + Z_{cog}^{(4)})/2$
$Z_{cog}^{(3)} = \frac{\sum_{i=1}^{3} Q_i z_i}{\sum_{i=1}^{3} Q_i}$
cm
½W

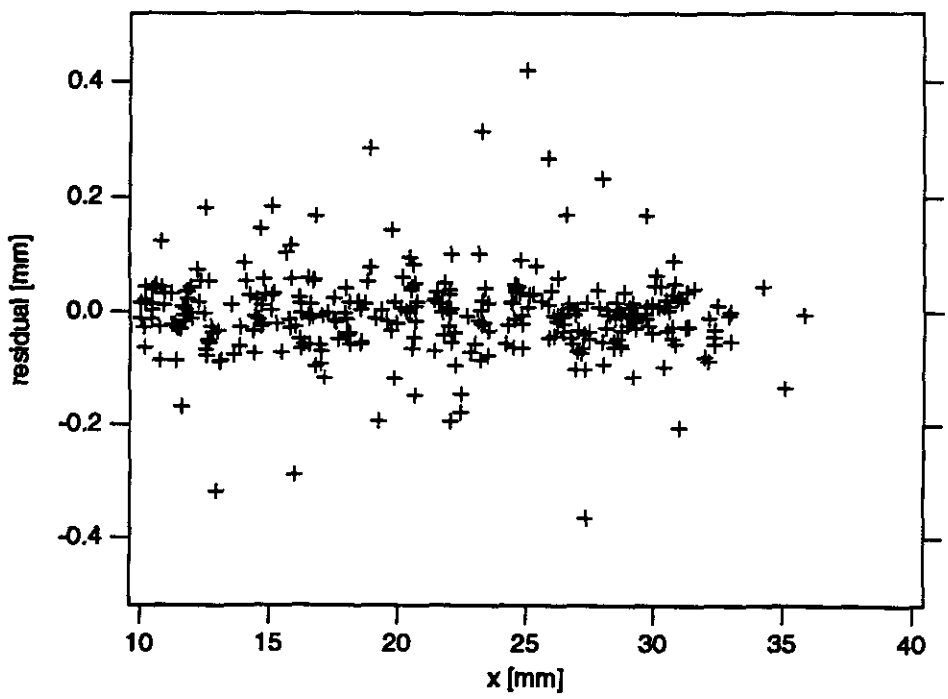

Z(cog) − Z(real) Before Correction (wire disp = 0.5 mm)
0
−20
−40
−60
−80
−100
0
0.04
0.08
0.12
0.16
0.2
0.24
zreal (in units of a)

Reults (perliminary)

- single plane resolution 96.3 μm
- relative systematic strip misalignment $\leq$ 17 μm


Run 414, Kwongs method
no systematic correction
sigma = 53.1 (130.0) µm
mm
cnt
residual [mm]
x [mm]
deg


Run 414, Kwongs method
80 µm sin-correction
sigma = 39.3 (96.3) µm
50
40
30
20
10
0
-0.50
-0.25
0.00
0.25
0.50


residual [mm]
0.4
0.2
0.0
-0.2
-0.4
10
15
20
25
30
35
40
x [mm]

Short-term Program (by Jan 15, 93)

- study angle dependence of resolution
- study HV dependence of resolution
- study gas dependence (fast vs standard)
- remove low momentum muons (software/hardware)
- increase acceptance (additional 16 preamp channels)

Near-term Program (by March 15, 93)

- study dependence on resistivity of carbon coating (0.4 to 4.0 kΩ per square)
- study timing of wire signals (install a fourth layer of chambers)
- resolution in streamer mode

Irwin Pless

RPC - RDT Tests

SSC MUON MEETING

19 NOVEMBER 1992

IRWIN A. PLESS

RPC AND RDT

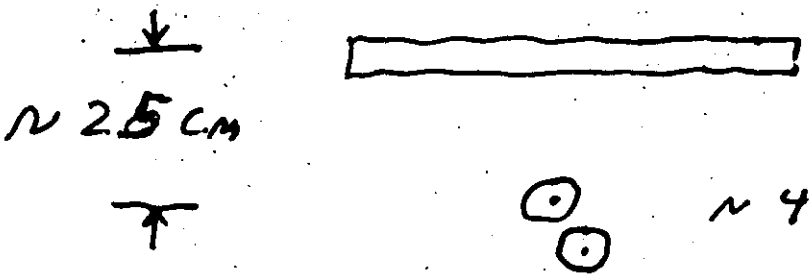
WORK DONE BY:

E.	ABLES	LLNL
J.	MAUGER	LLNL
C.	WUEST	LLNL
P.	DU	TENN
R.	MILLER	MSU
* A.	GONZALEZ	SSC
Y.	BONUSHKIN	SSC
D.	SHACKELFORD	SSC
C.	MILNER	SSC

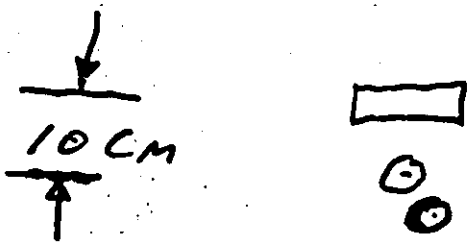
PURPOSE:

MEASURE THE CROSS TALK BETWEEN RPC AND PDT

EXPERIMENTAL SET UP:



RPC 1M x 2M
ITALIAN - BAKELITE
~4CM Φ x 4M RDT TUBES
MSU



RPC 20 INCHES x 20 INCHES
LLNL HIGH RATE PLASTIC
~4 CM Φ x 4M RDT TUBES
MSU

EXPERIMENTAL PROCEEDURE:

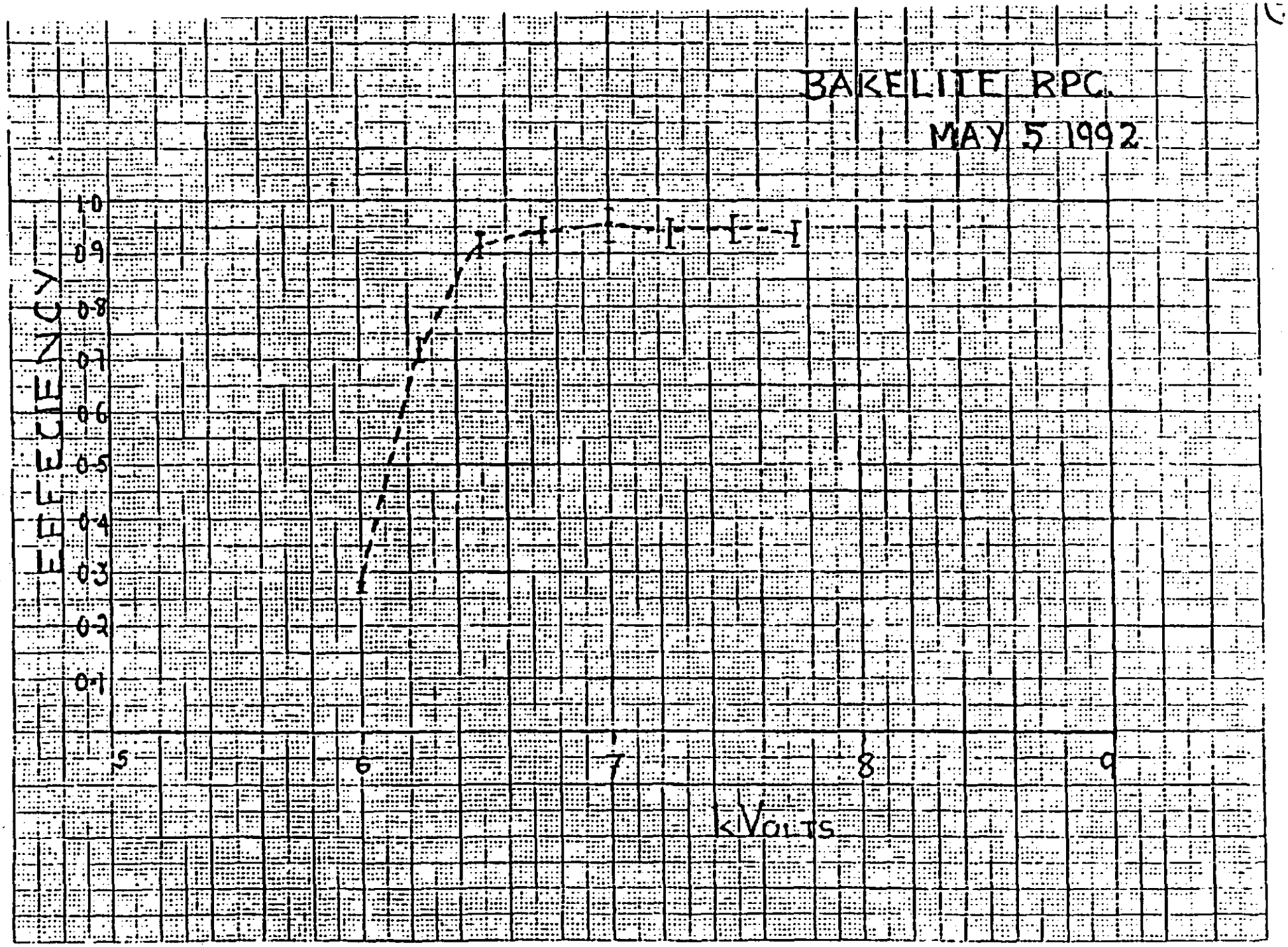
A. COUNTING RATE OF SINGLE RDT TUBES AS A FUNCTION OF RPC COUNTING RATE

B. USING TWO PDT TUBES TO DEFINE A COSMIC RAY - MEASURE RPC EFFICIENCY PLATEAU

C. LOOK DIRECTLY AT THE RDT WIRE AND LOOK FOR RDT-RPC CROSS TALK

RESULT - <u>NO</u> MEASURABLE CROSS TALK

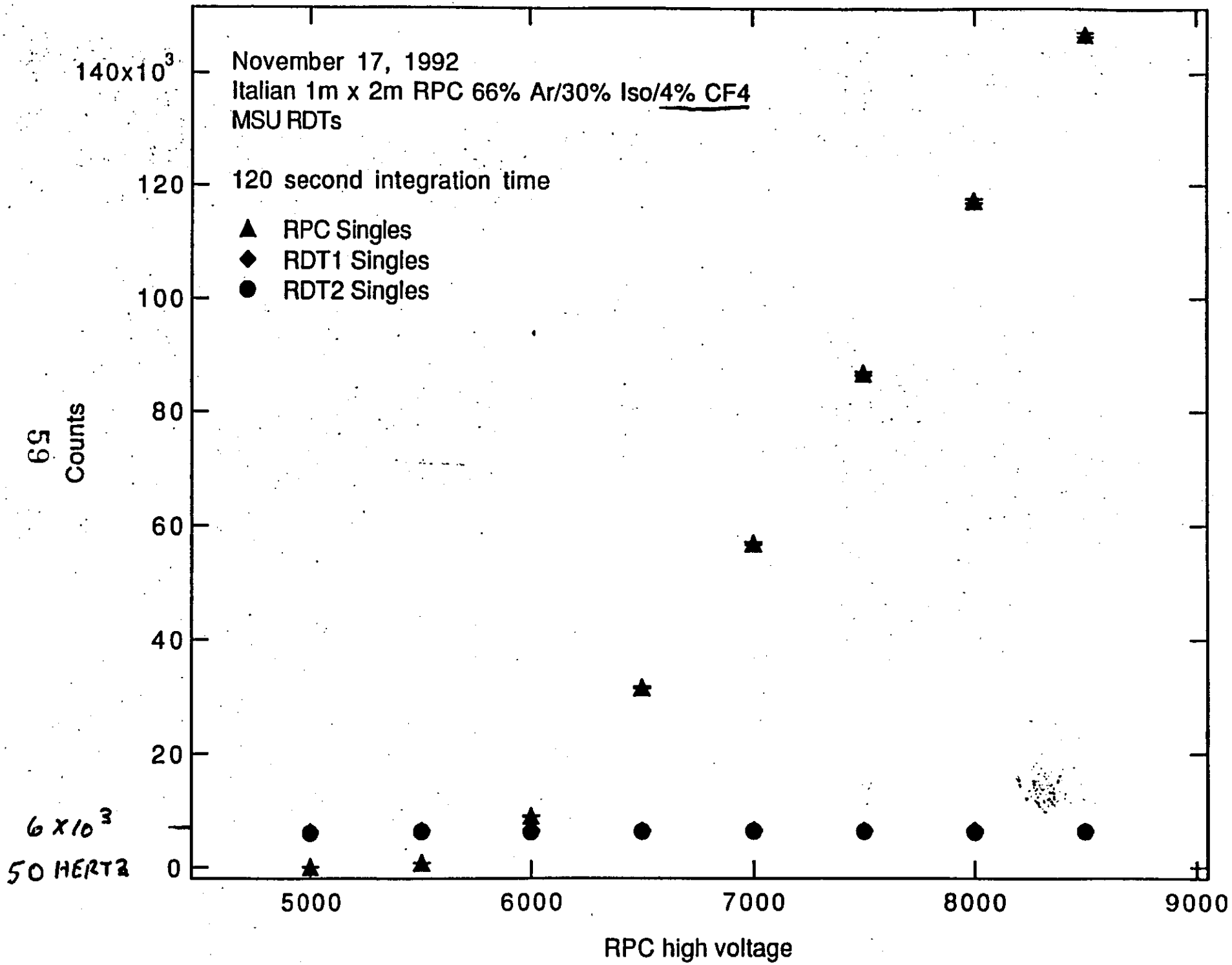
ANY CROSS TALK IS COMPLETELY MASKED BY F.M. STATION BACKGROUND.

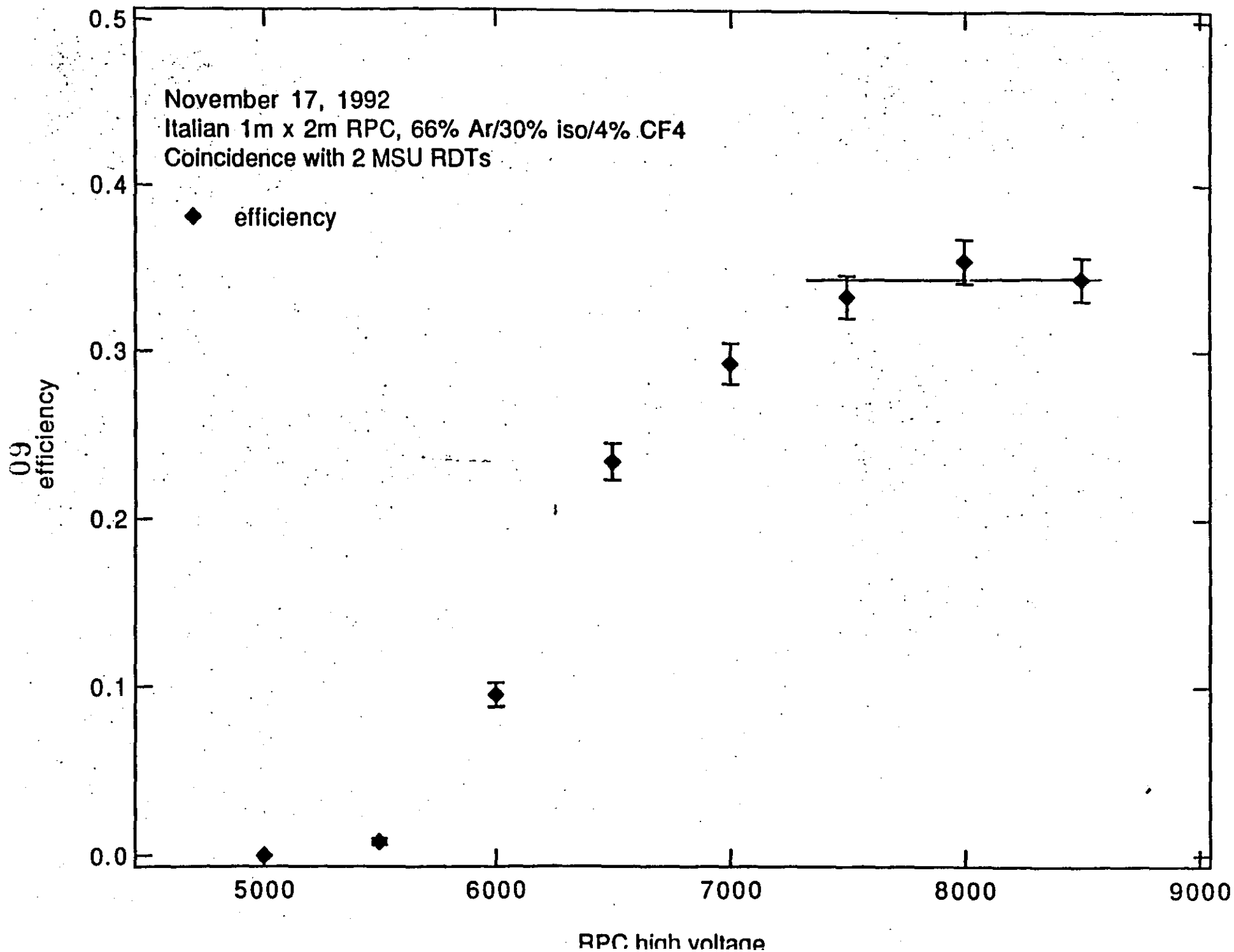


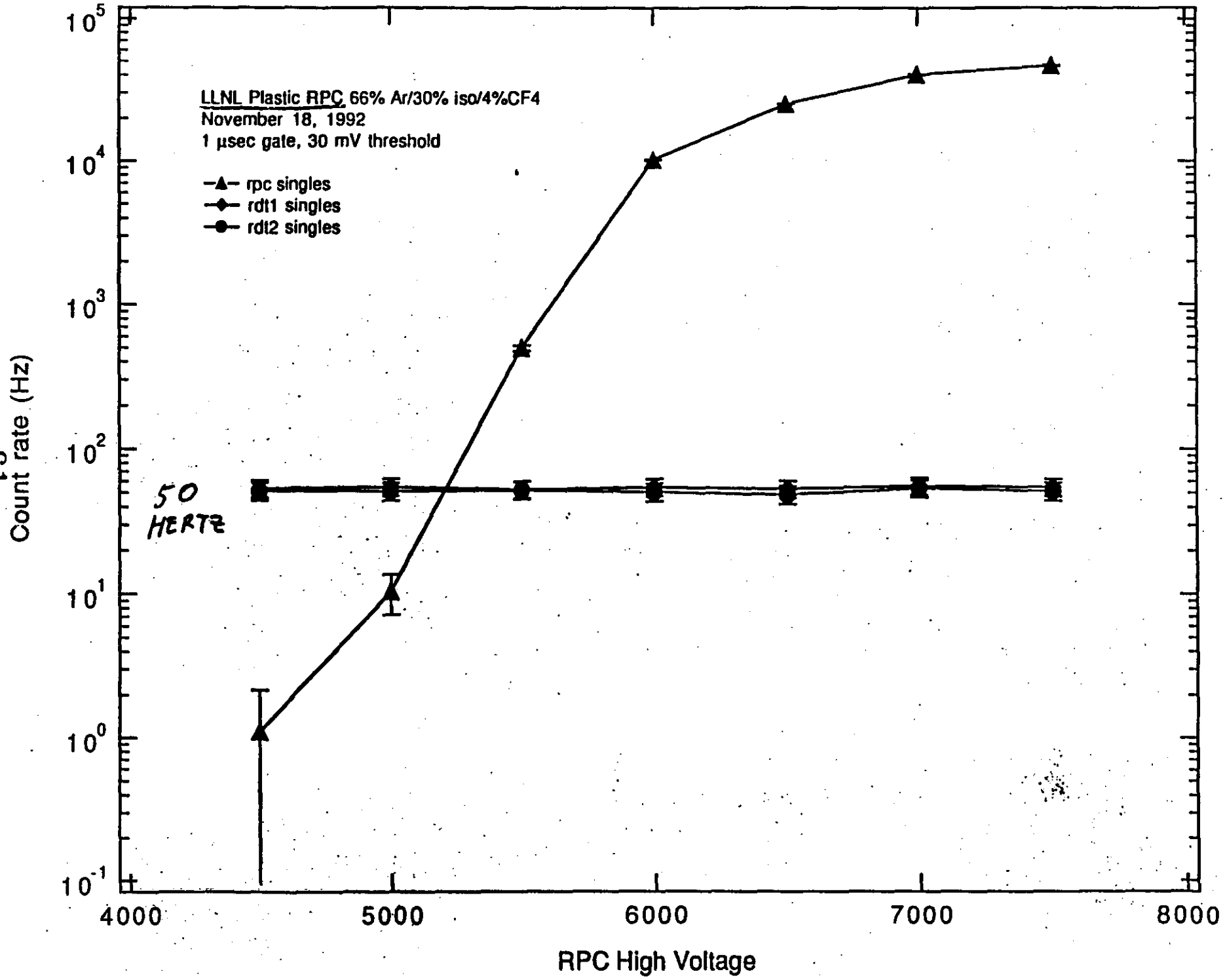
ARGON - 66% ISO 30% F13B1 4%

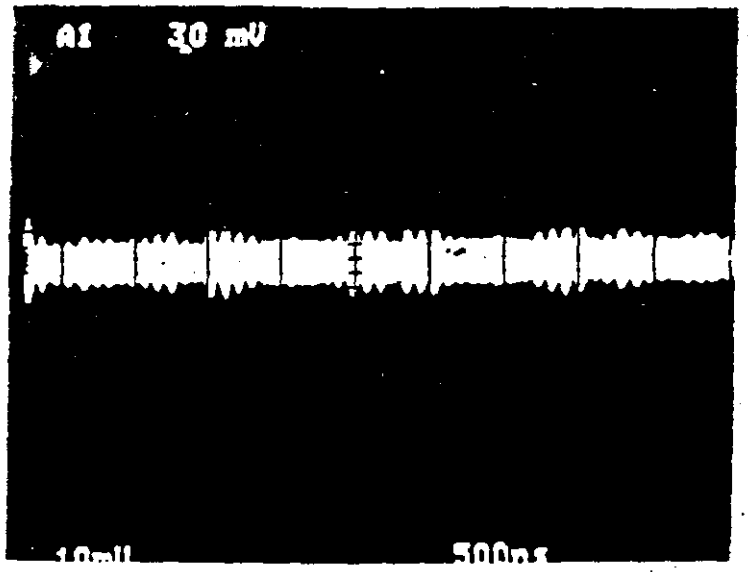
11/18 15:32 58 7312025 #02

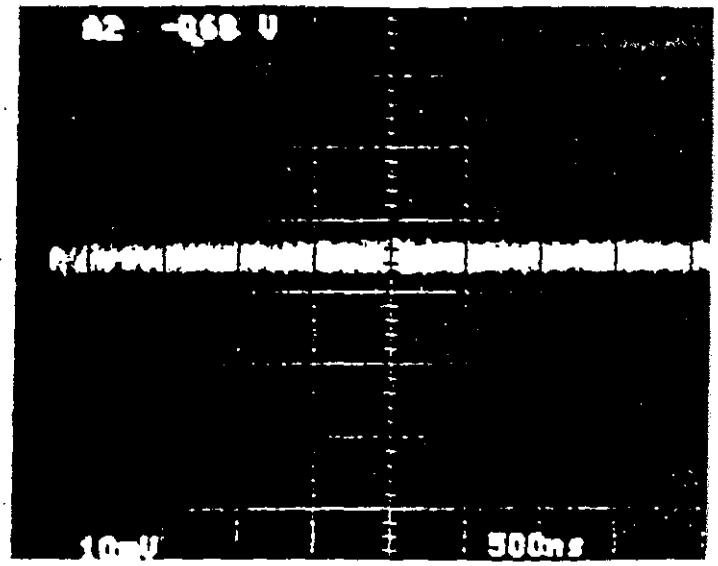
46 1510


November 17, 1992
Italian 1m x 2m RPC 66% Ar/30% Iso/4% CF4
MSU RDTs
120 second integration time
RPC Singles
RDT1 Singles
RDT2 Singles
140x10^3
120
100
80
60
40
20
6 x10^3
50 HERTZ
0
Counts
5000
6000
7000
8000
9000
RPC high voltage


November 17, 1992
Italian 1m x 2m RPC, 66% Ar/30% iso/4% CF4
Coincidence with 2 MSU RDTs
efficiency
efficiency
RPC high voltage
0.0
0.1
0.2
0.3
0.4
0.5
5000
6000
7000
8000
9000

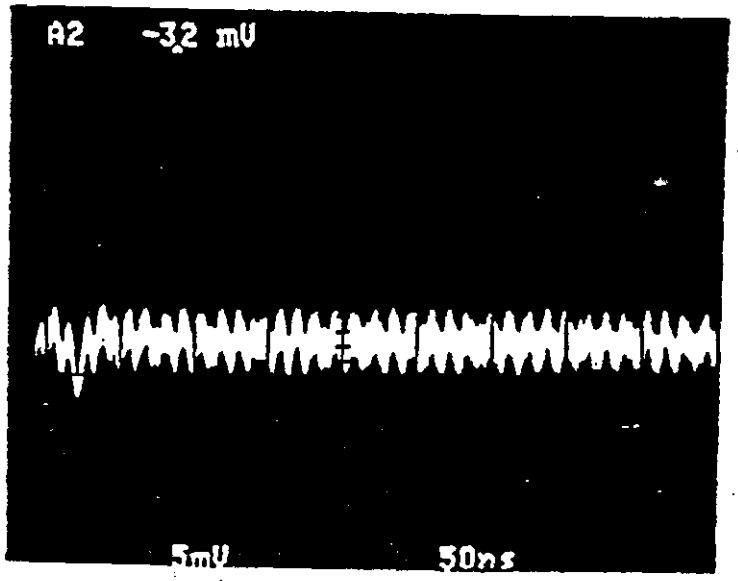

LLNL Plastic RPC 66% Ar/30% iso/4%CF4
November 18, 1992
1 µsec gate, 30 mV threshold
rpc singles
rdt1 singles
rdt2 singles
50 HERTZ
Count rate (Hz)
RPC High Voltage
10^5
10^4
10^3
10^2
10^1
10^0
10^{-1}
4000
5000
6000
7000
8000

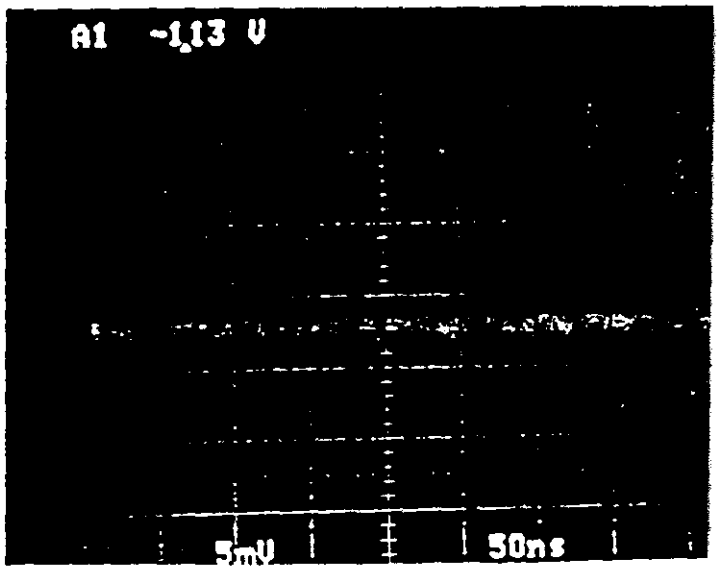




MSU RDT

1 MILLIVOLT PEAK TO PEAK





DUBNA RDT

100 MICROVOLTS PEAK TO PEAK

SUMMARY

WE HAVE LOOKED FOR CROSS TALK BETWEEN BOTH THE ITALIAN AND THE LLNL RPCs AND THE MSU RDT.

NO CROSS TALK WAS FOUND.

EVEN AT THE LEVEL OF 1000 RPC PULSES FOR EACH RDT PULSE THERE WAS NO MEASURABLE CROSS TALK.

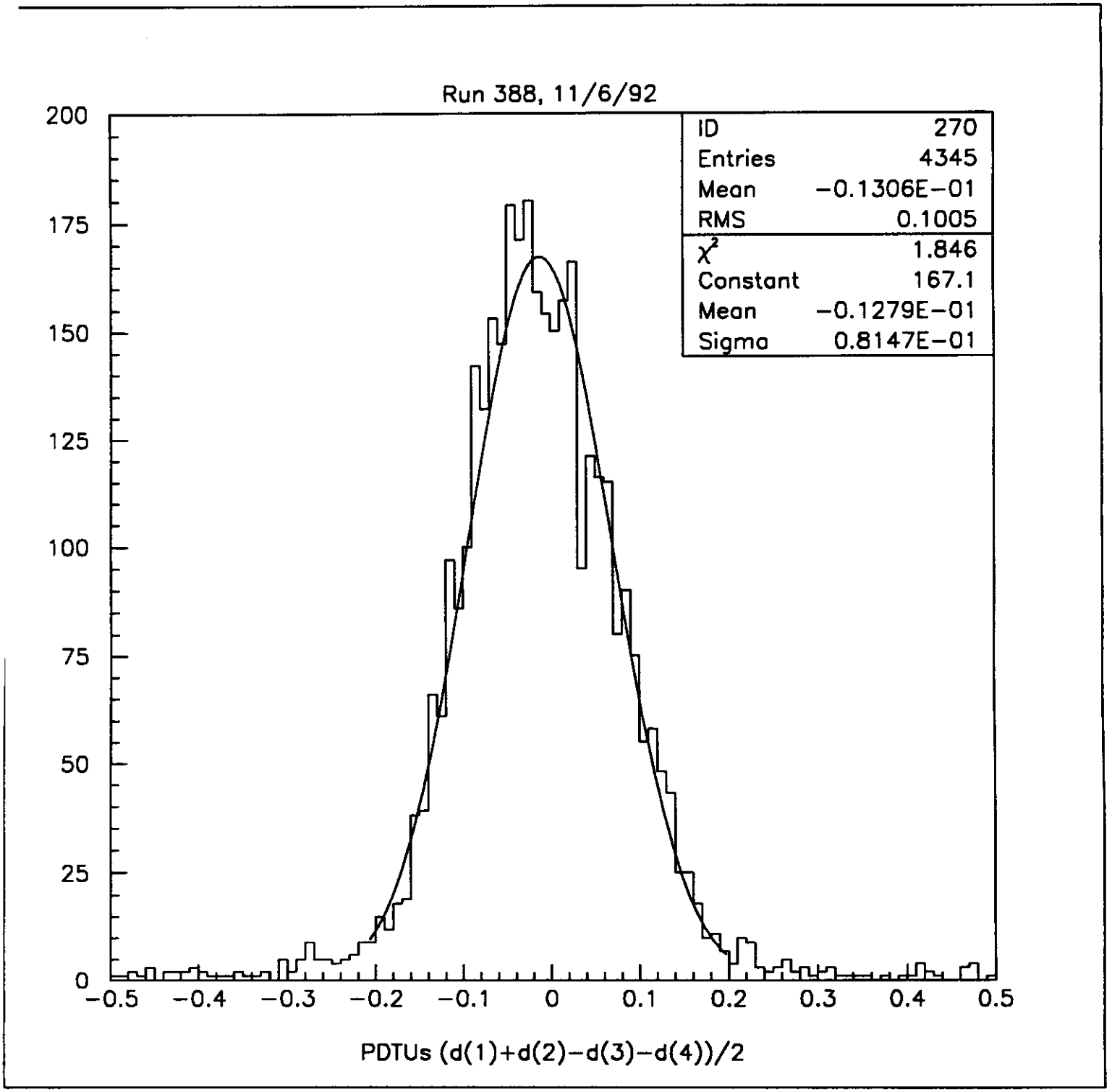
LOOKING AT THE RDT WIRE, ANY RPC-RDT CROSS TALK WAS MASKED BY F.M. STATION PICK UP ON THE RDT WIRE.

WE WILL MAKE THE SAME MEASUREMENTS WITH THE DUBNA RDT SYSTEM.

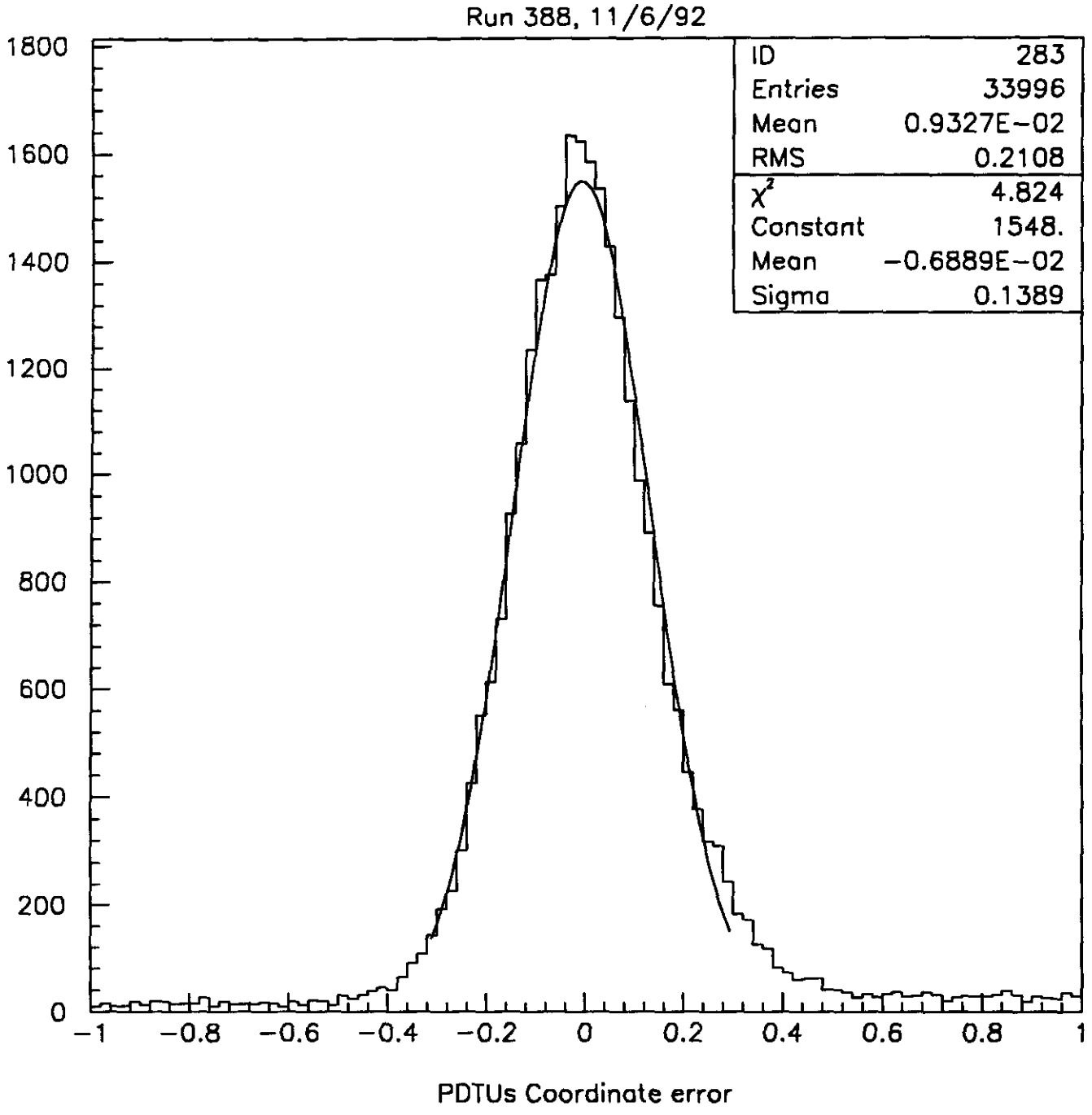
Bob Miller

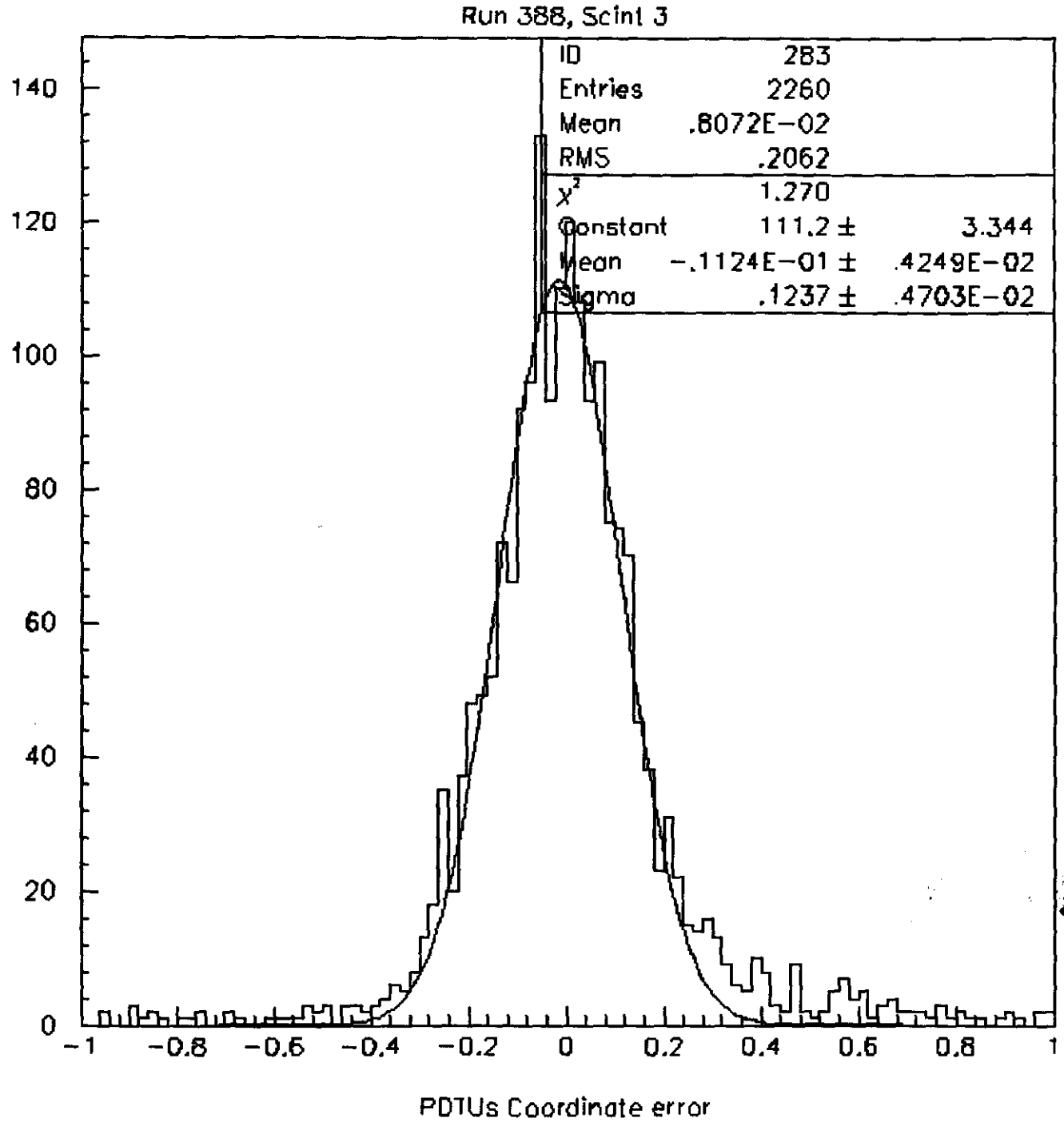
RDT

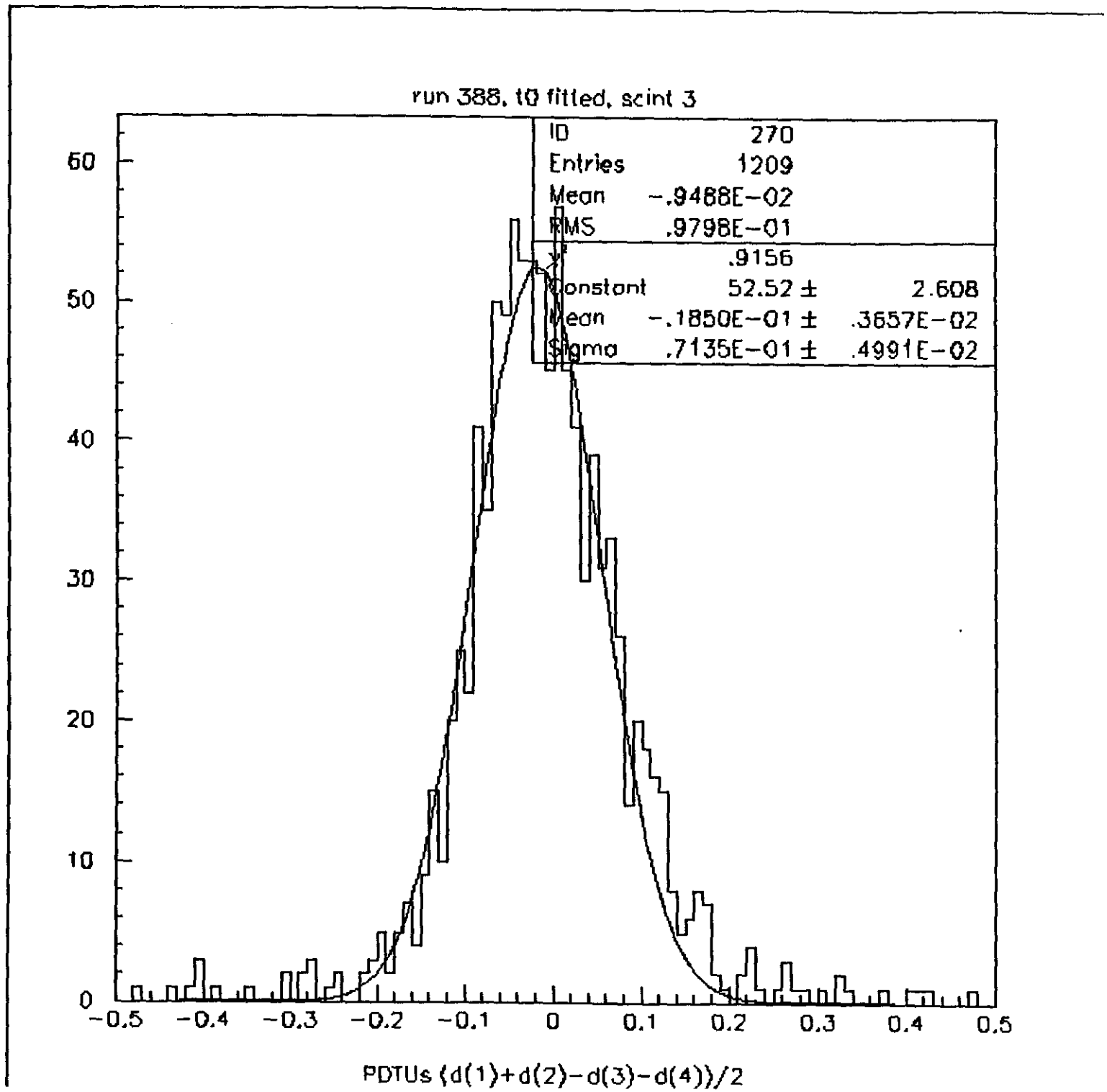
Bob Miller

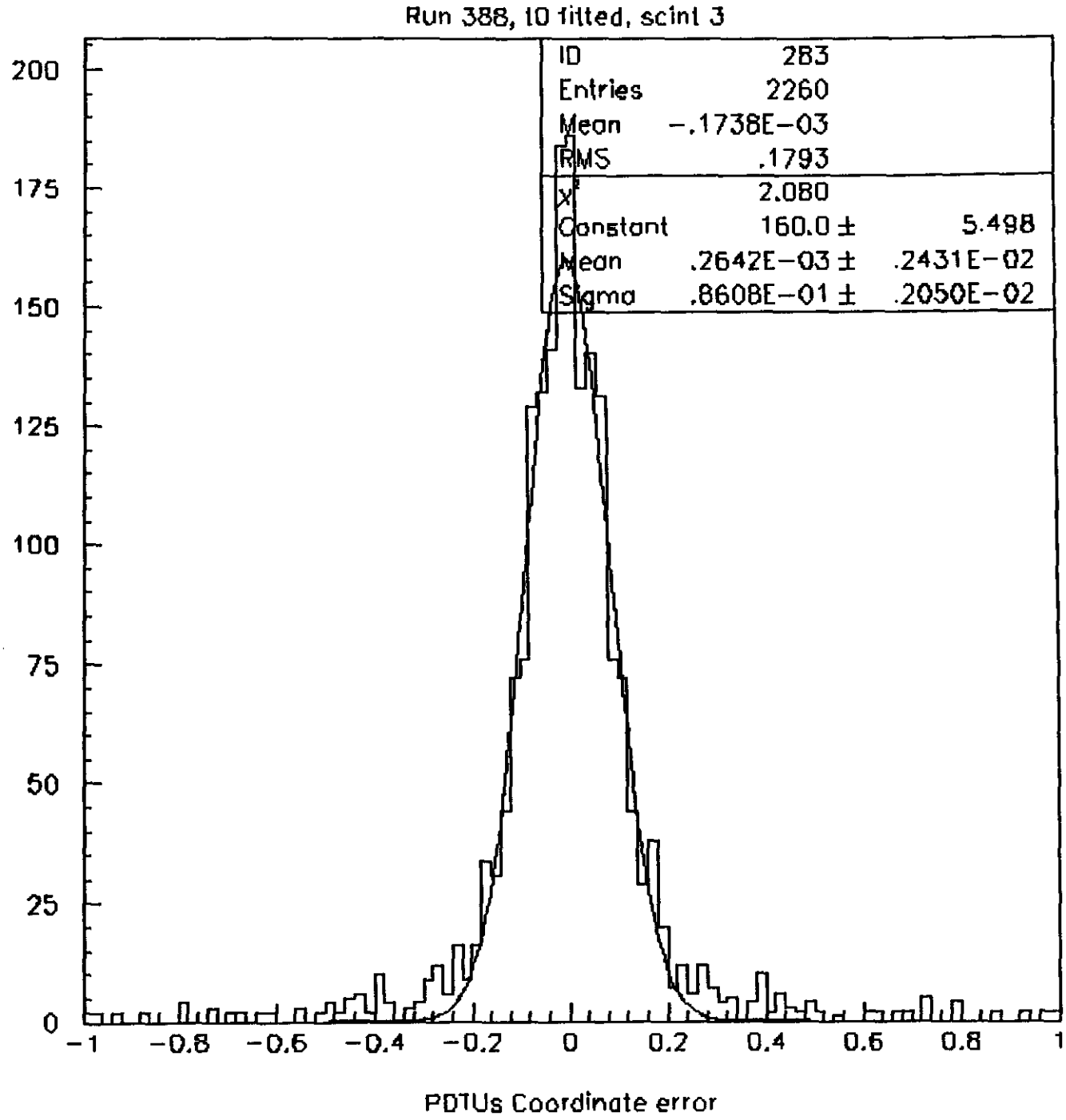

Run 388, 11/6/92
ID 270
Entries 4345
Mean −0.1306E−01
RMS 0.1005
χ² 1.846
Constant 167.1
Mean −0.1279E−01
Sigma 0.8147E−01
200
175
150
125
100
75
50
25
0
−0.5
−0.4
−0.3
−0.2
−0.1
0
0.1
0.2
0.3
0.4
0.5
PDTUs (d(1)+d(2)−d(3)−d(4))/2

06/11/92 15.02


Run 388, 11/6/92
ID 283
Entries 33996
Mean 0.9327E−02
RMS 0.2108
χ² 4.824
Constant 1548.
Mean −0.6889E−02
Sigma 0.1389
1800
1600
1400
1200
1000
800
600
400
200
0
−1
−0.8
−0.6
−0.4
−0.2
0
0.2
0.4
0.6
0.8
1
PDTUs Coordinate error


Run 388, Scint 3
ID 283
Entries 2260
Mean .8072E-02
RMS .2062
χ² 1.270
Constant 111.2 ± 3.344
Mean -.1124E-01 ± .4249E-02
Sigma .1237 ± .4703E-02
140
120
100
80
60
40
20
0
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1
PDTUs Coordinate error


run 388, t0 fitted, scint 3
ID 270
Entries 1209
Mean -.9488E-02
RMS .9798E-01
χ² .9156
Constant 52.52 ± 2.608
Mean -.1850E-01 ± .3657E-02
Sigma .7135E-01 ± .4991E-02
0
10
20
30
40
50
60
-0.5
-0.4
-0.3
-0.2
-0.1
0
0.1
0.2
0.3
0.4
0.5
PDTUs (d(1)+d(2)-d(3)-d(4))/2


Run 388, 10 fitted, scint 3
ID 283
Entries 2260
Mean -.1738E-03
RMS .1793
χ² 2.080
Constant 160.0 ± 5.498
Mean .2642E-03 ± .2431E-02
Sigma .8608E-01 ± .2050E-02
200
175
150
125
100
75
50
25
0
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1
PDTUs Coordinate error

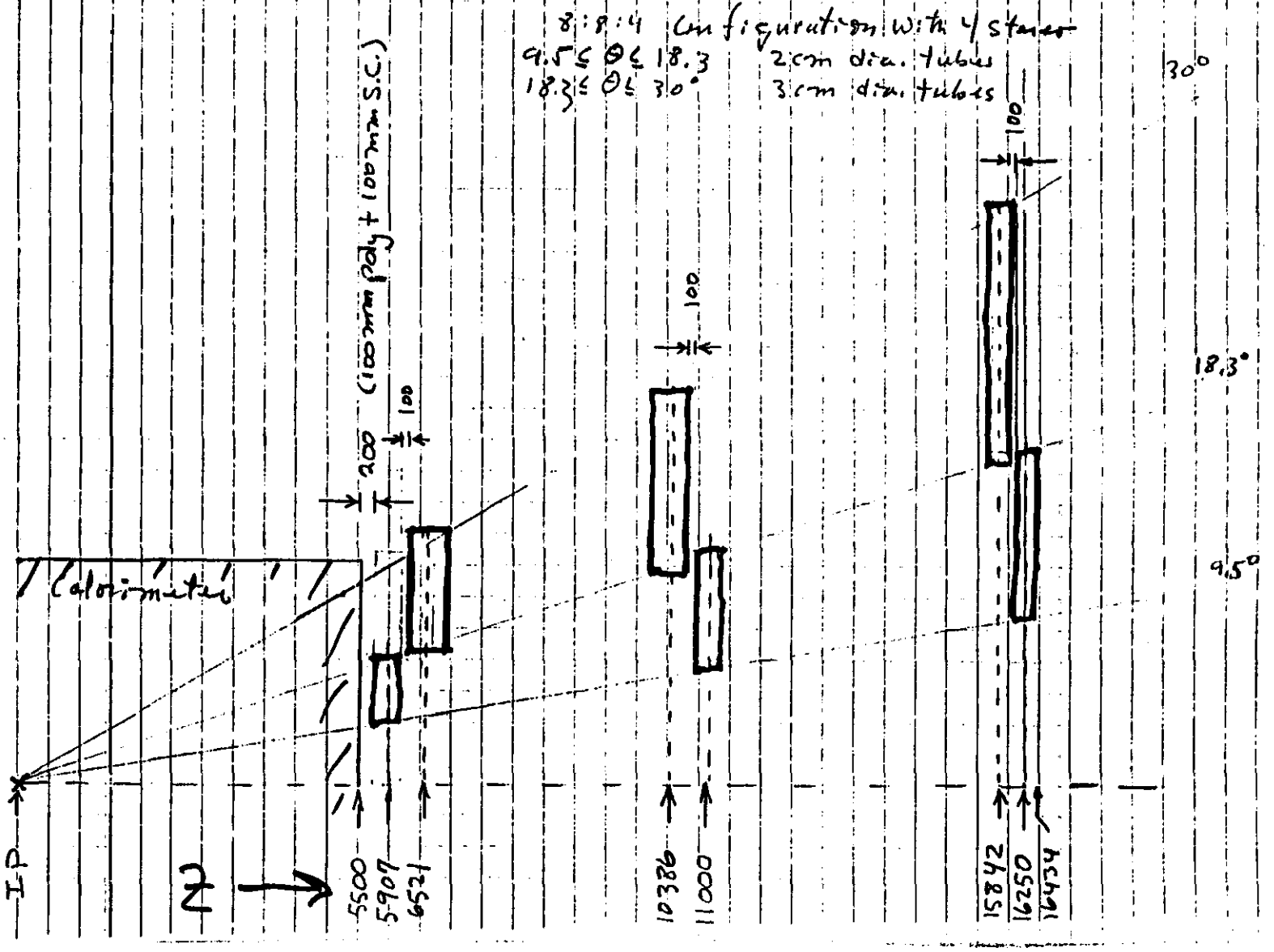
Frank Taylor

Deployment of RDTs in Endcaps

Layout of a RDT EndCap Design

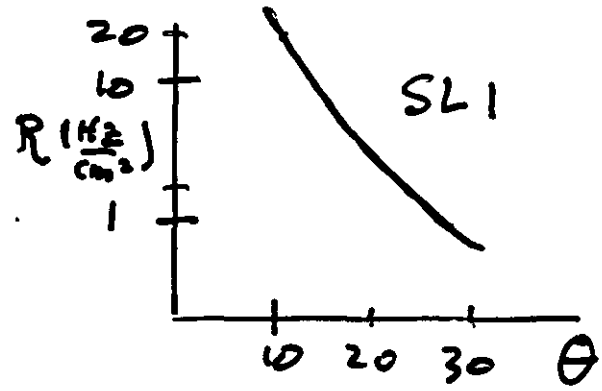
11/11/92

8:8:4 Configuration with 4 stacks
$9.5 \le \theta \le 18.3$ 2cm dia. tubes
$18.3 \le \theta \le 30°$ 3cm dia. tubes



RDT Counting Rates

(1) Charged Particles:



$10^\circ \leq \theta \leq 18.3^\circ$

2 cm dia. tubes

$R_c \simeq 2.3\,kHz$ @ 10^{33}

(2) Neutrons: $f \sim 10^5$ n/cm²

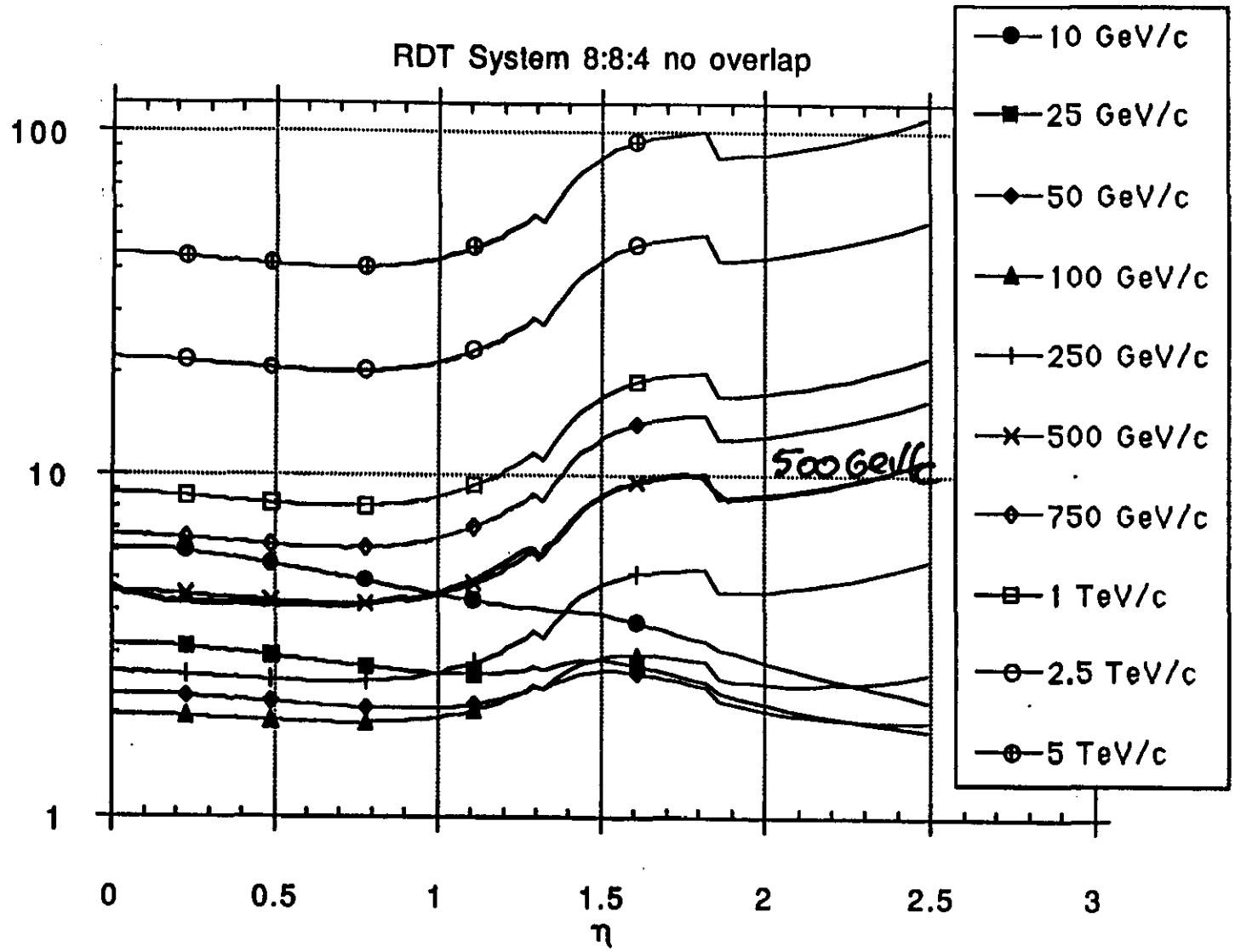
$R_n \simeq 10^5 \times 2 \times 90 \times 0.5 \times 10^{-2}$ SL1

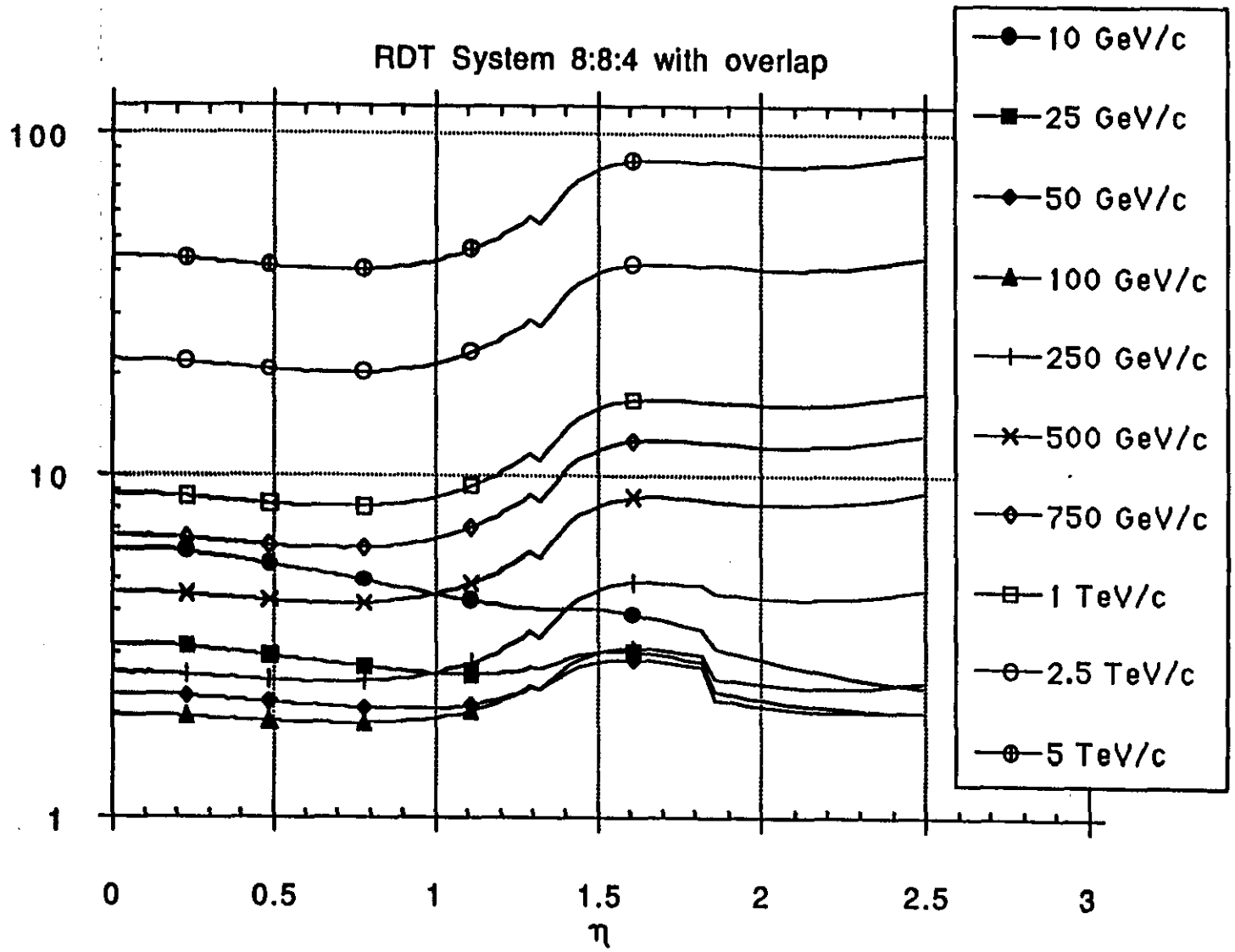
$\simeq 90\,kHz$ @ 10^{33}

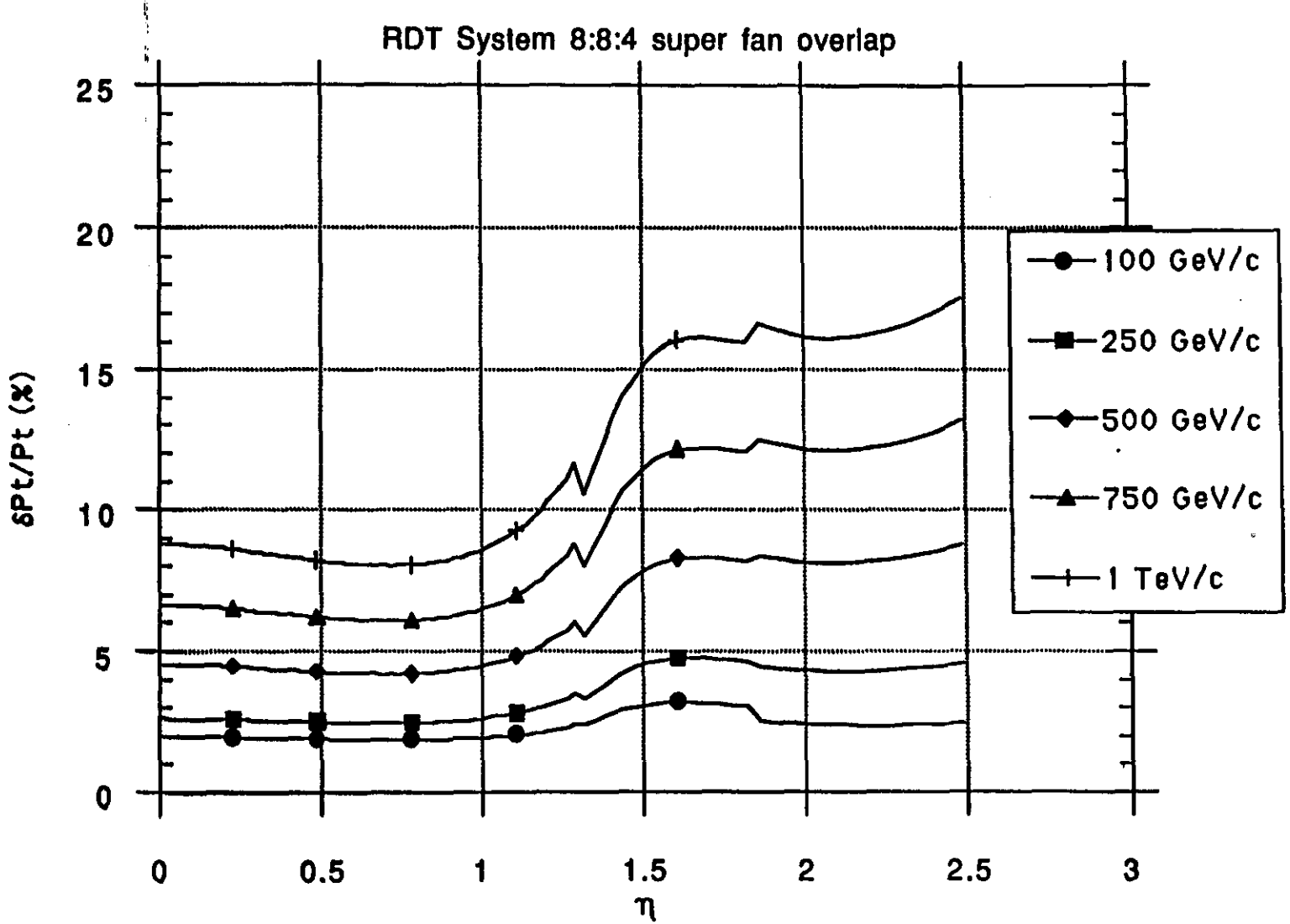
Occupancy (200 ns drift time) $\simeq 3.6\%$

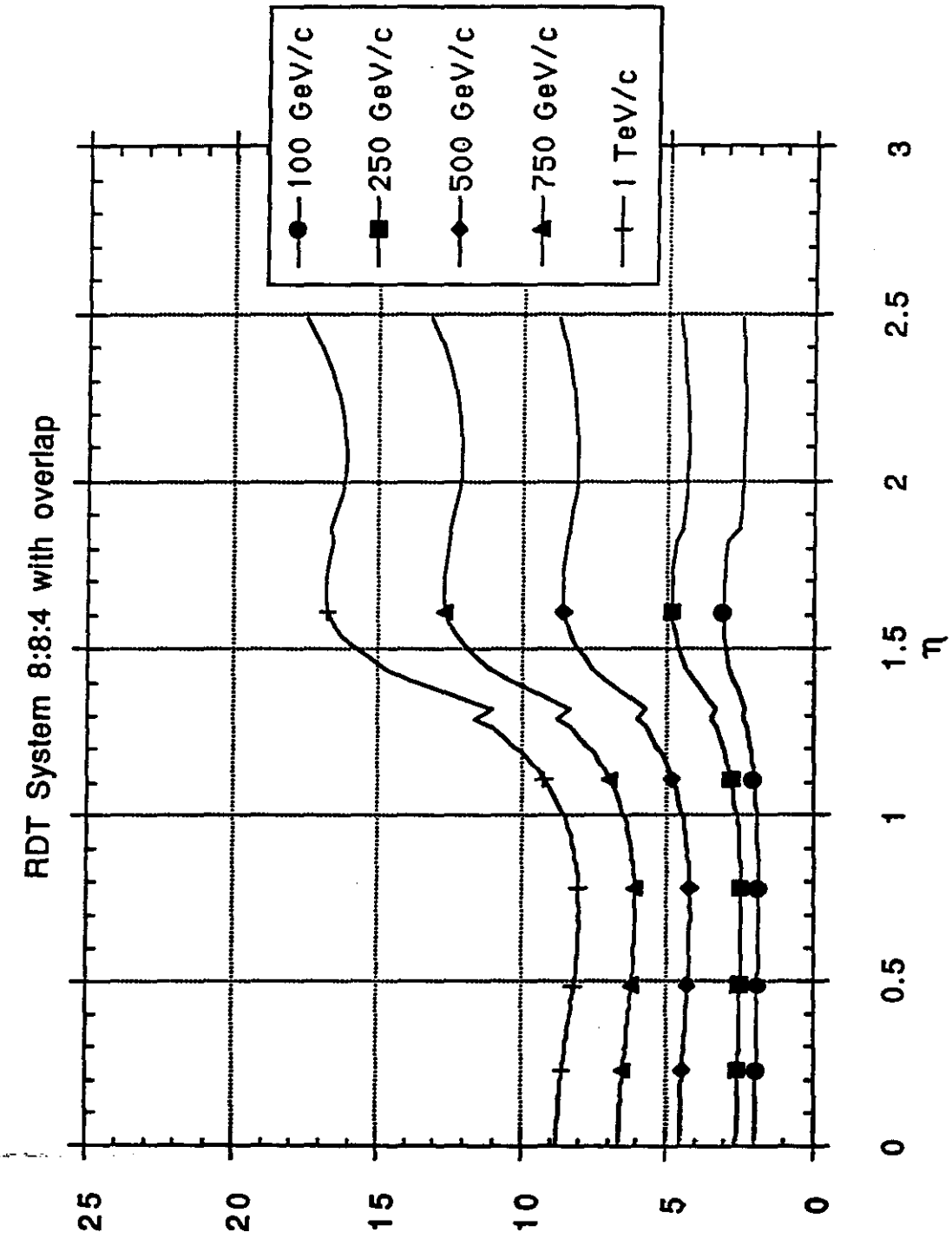
Want $f \lesssim 10^4$ Hz/cm² – but rates will prob. be dominated by neutrons in any case

8:8:4 100 μm System



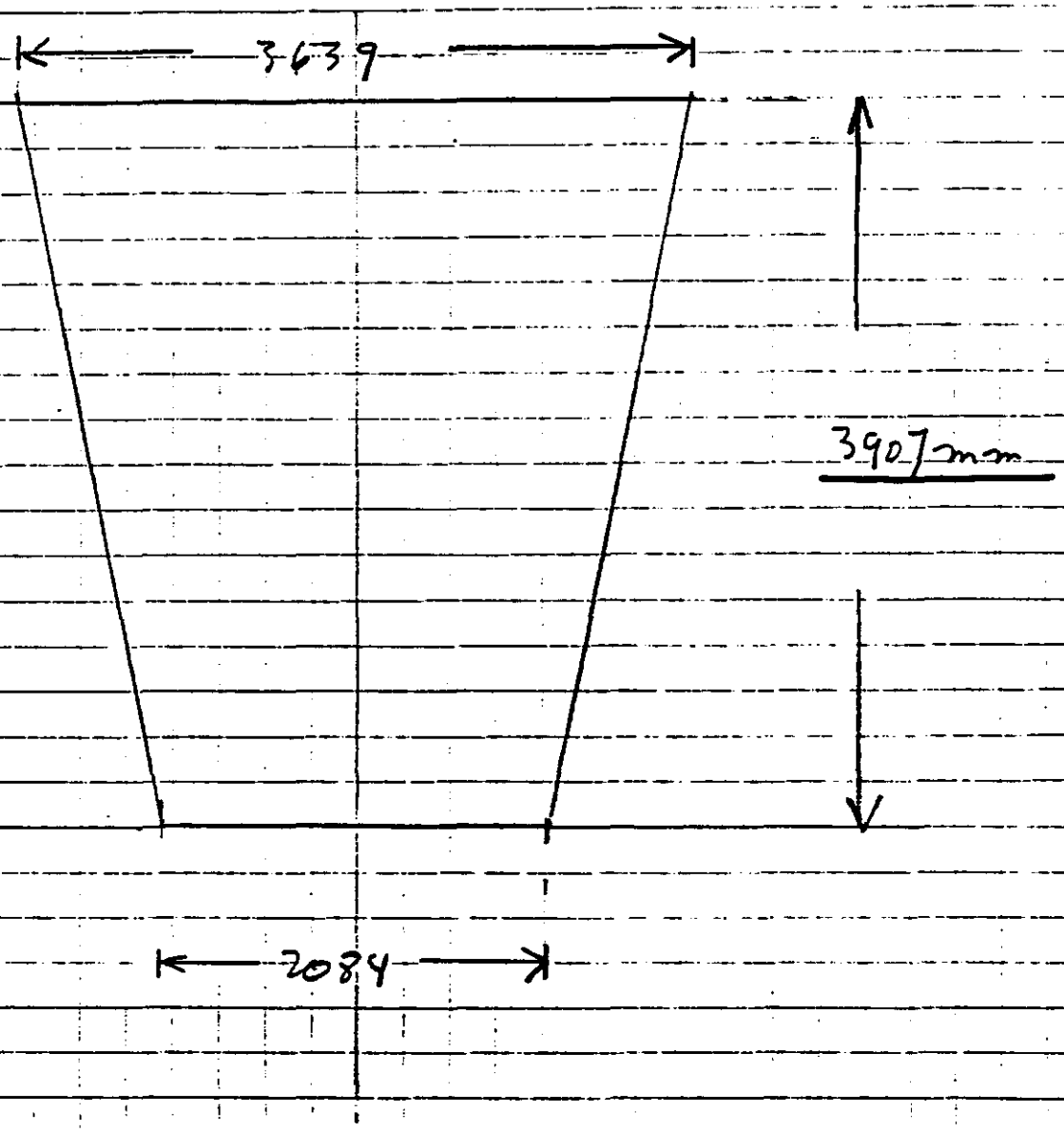

RDT System 8:8:4 with overlap
100
10
1
0
0.5
1
1.5
2
2.5
3
η
10 GeV/c
25 GeV/c
50 GeV/c
100 GeV/c
250 GeV/c
500 GeV/c
750 GeV/c
1 TeV/c
2.5 TeV/c
5 TeV/c


RDT System 8:8:4 super fan overlap
δPt/Pt (%)
25
20
15
10
5
0
0
0.5
1
1.5
2
2.5
3
η
100 GeV/c
250 GeV/c
500 GeV/c
750 GeV/c
1 TeV/c

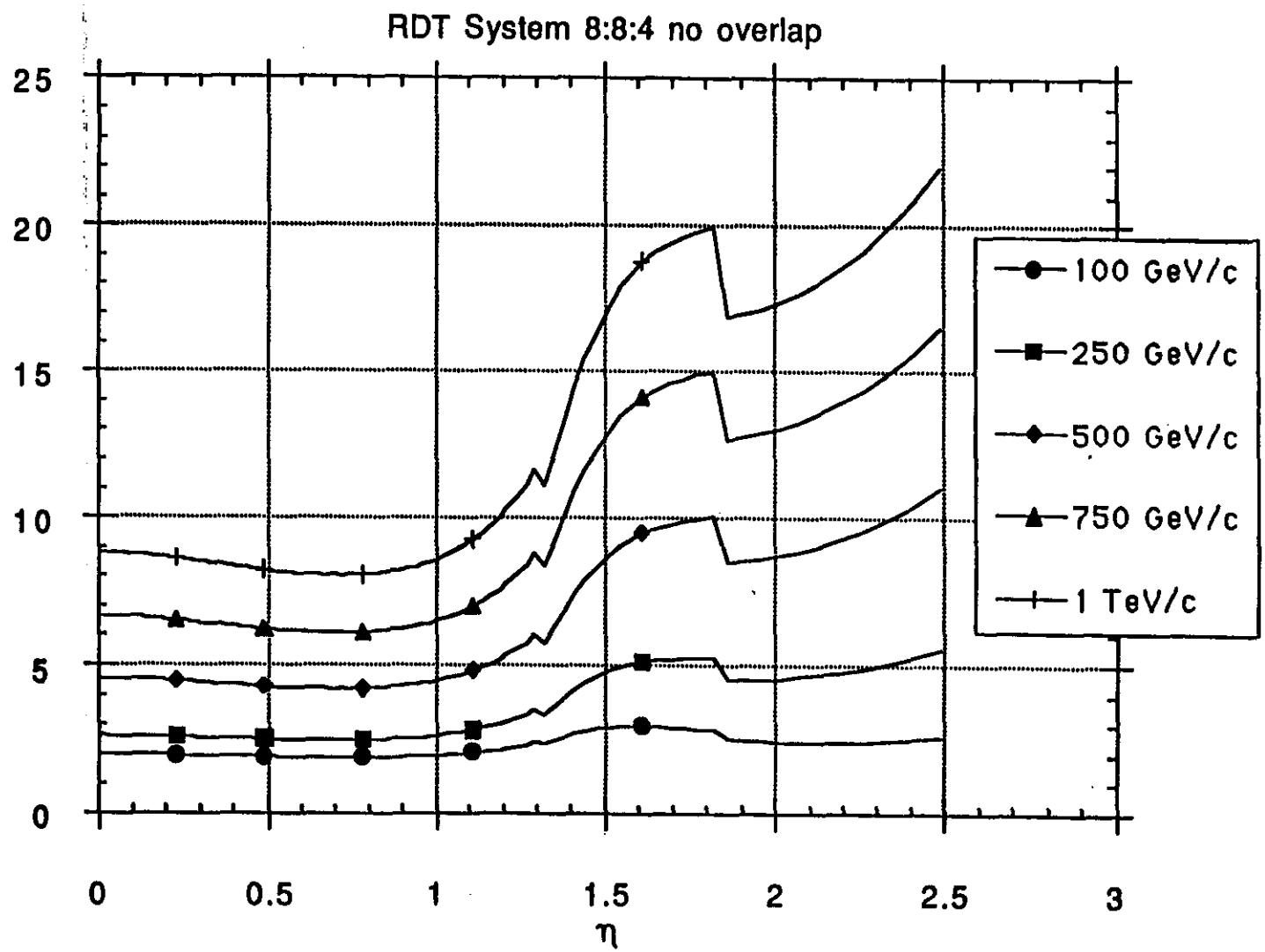

RDT System 8:8:4 with overlap
100 GeV/c
250 GeV/c
500 GeV/c
750 GeV/c
1 TeV/c
25
20
15
10
5
0
0
0.5
1
1.5
2
2.5
3
η

$9.5^\circ \leq \theta \leq 18.3^\circ$

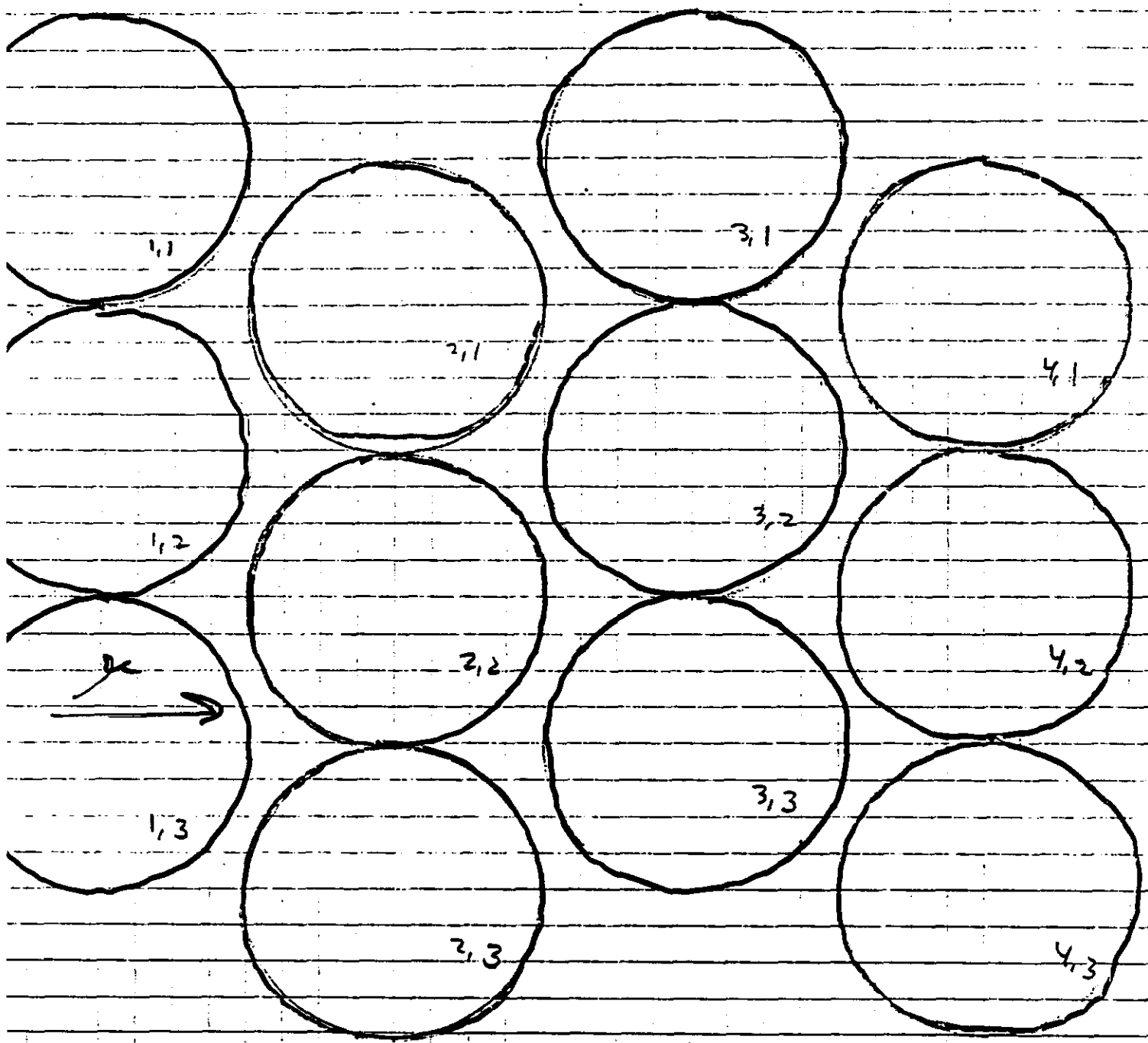
largest chamber (SL3 outer angle region)



11/14/92


RDT System 8:8:4 no overlap
25
20
15
10
5
0
0
0.5
1
1.5
2
2.5
3
η
100 GeV/c
250 GeV/c
500 GeV/c
750 GeV/c
1 TeV/c

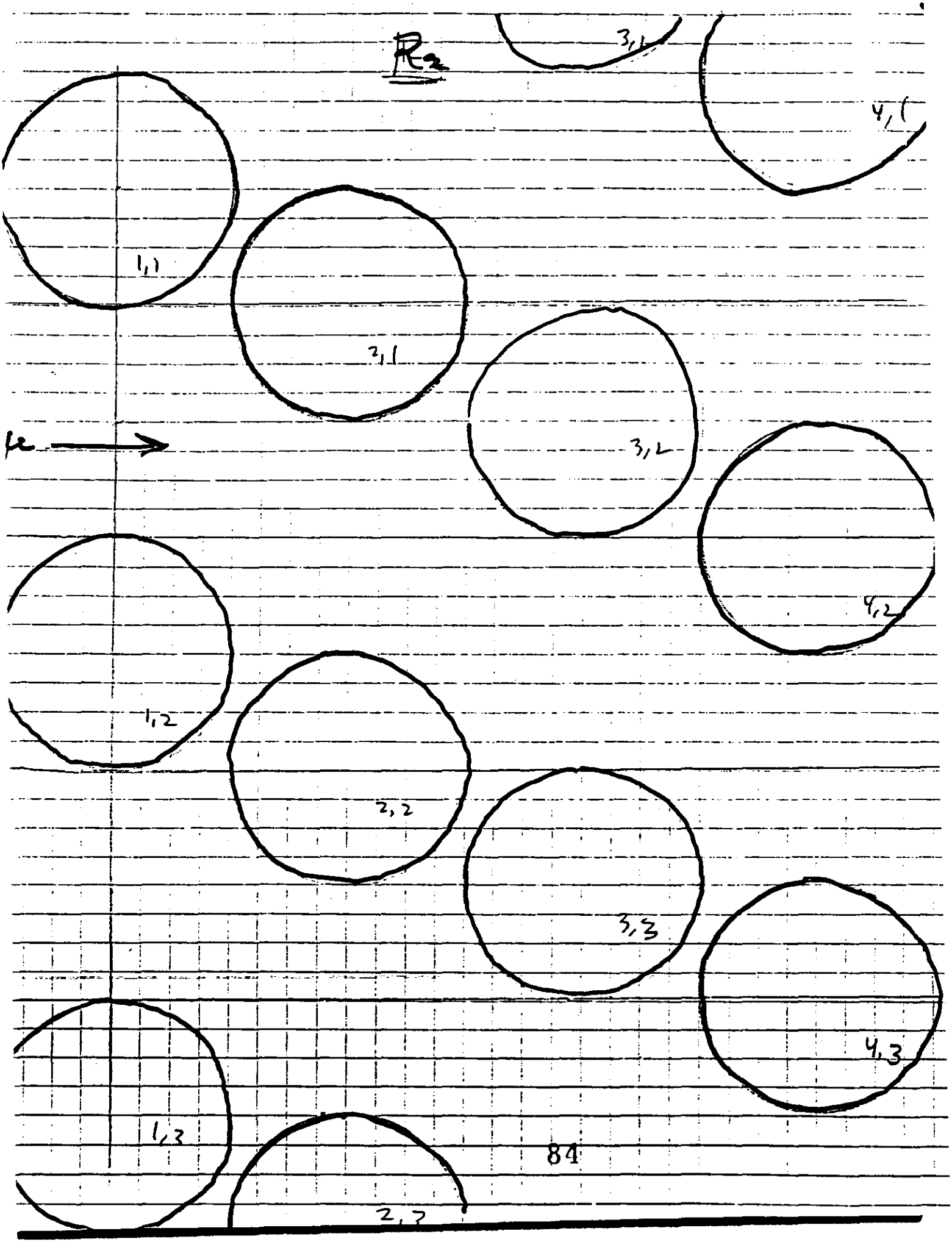
$\underline{B_k}$



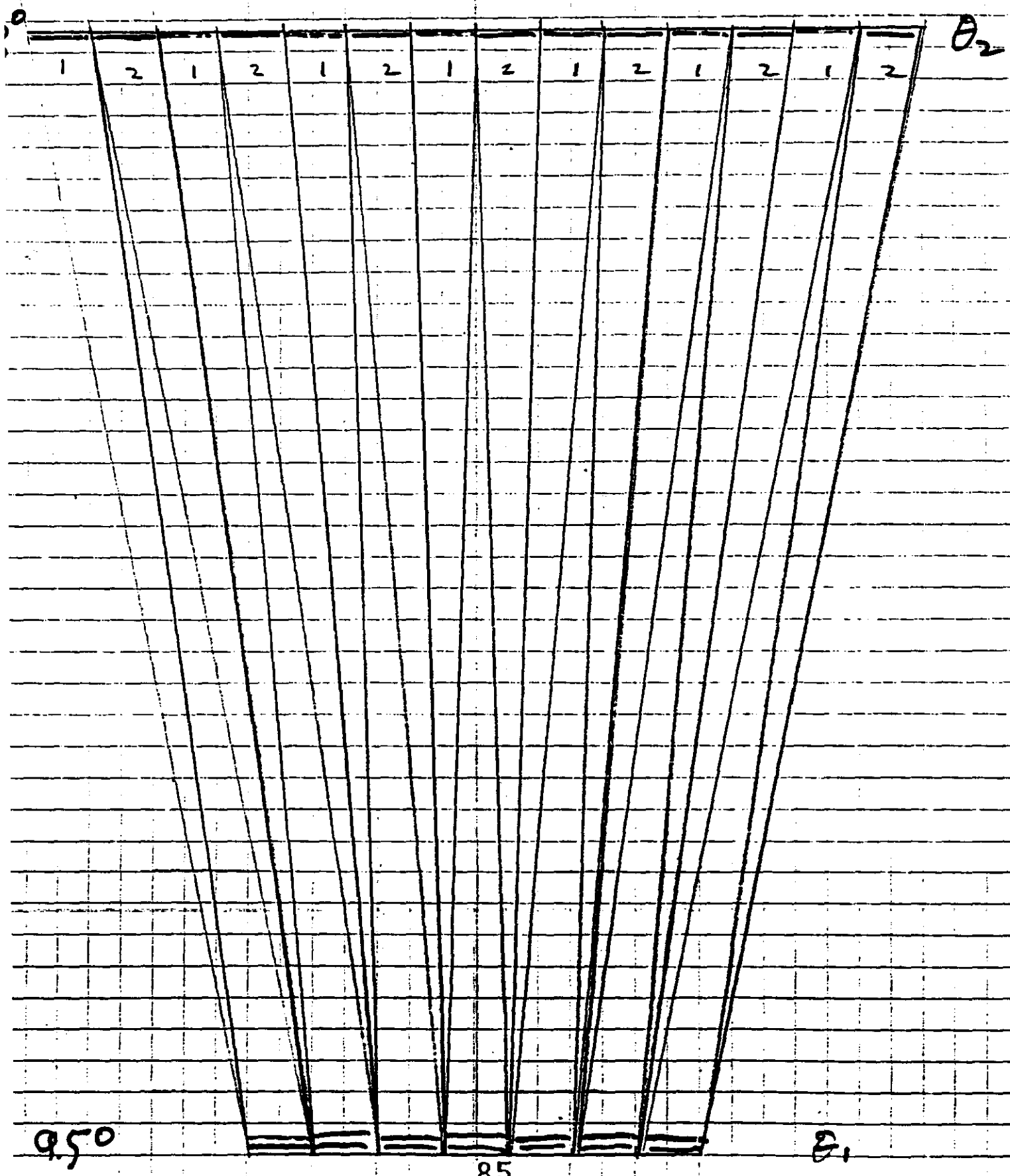
$$N(\theta) = N_0 \, Tan(\theta_2) / Tan(\theta)$$

$$\frac{N(\theta_1)}{N_0} = 2 \, , \quad \frac{N(\theta_2)}{N_0} = 1$$

R_2



$$N(\theta) = N_0 \, \mathrm{Tan}(\theta_2)/\mathrm{Tan}(\theta)$$



Approx. Sizes of chambers:

$9.5° \leq \theta \leq 18.3°$ 2cm tubes

	Z	R_1	R_2	ΔR	ℓ_1	ℓ_2	$N_{tubes/layer}$	N
SL1	5907	988	1954	966	393	773	39 (8)	31
SL2	11000	1841	3638	1797	732	1447	72 (8)	57
SL3	16250	2719	5374	2655	1082	2138	107 (4)	42
							Σ	131

$18.3° \leq \theta \leq 30°$ 3cm tubes

	Z	R_1	R_2	ΔR	ℓ_1	ℓ_2	$N_{tubes/layer}$	N
SL1	6521	2157	3765	1608	858	1498	50 (8)	4
SL2	10386	3435	5996	2561	1367	2385	80 (8)	6
SL3	15842	5239	9146	3907	2084	3639	121 (4)	4
							Σ	152

Σ tubes/sector = 2840 ⇒ endcaps 90,880 tubes

plus stereo ≈ 30,000 tubes & small a

End cap System = 121 k tubes

Andrey Korytov

RDT - Wire Sag

11/19/19

A. Korytov
M.I.T.

One more time
about wire sag.

CONCLUSIONS:

$R = 1.25\,cm$ $\qquad \rho_0 = 20\ g/cm^3$

$L = 4.75\,m$

$r_0 = 50\,\mu m$ (100 μm wire!)

$T = 1.2\ kg$

$V(@\ 1\,atm) \sim 5\,kV$ $\qquad V(@\ 4\,atm) \sim 10\,kV$

$$\varkappa = \frac{V^2}{R^2 \left(\ln \frac{R}{r_0}\right)^2} (2\pi\varepsilon_0)$$

⊛ GRAVIT. Sag: $\quad S_0 = \frac{1}{2} \frac{(\pi r_0^2 \rho_0) g}{T} \left(\frac{L}{2}\right)^2 \qquad \underline{\underline{\sim 370\,\mu m}}$

⊛ Electrostatic Instability: $\quad V_0 = \frac{\pi}{\sqrt{2\pi\varepsilon_0}} \sqrt{T}\, \frac{R \ln R/r_0}{L} = \underline{\underline{21\,kV}}$

⊛ Electrost. Sag due to GRAVIT. SAG $\quad \Delta S \simeq \frac{1}{4} \frac{\varkappa}{T} \left(\frac{L}{2}\right)^2 \cdot S_0 \qquad \underline{\underline{13\,\mu m}}$ @ 5 kV; $\underline{\underline{52\,\mu m}}$ @ 10 kV

⊛ A Electrostatic Sag due to wire offset $\quad S \simeq \frac{1}{2} \frac{\varkappa}{T} \left(\frac{L}{2}\right)^2 \cdot \Delta$! $\qquad \underline{\underline{S \sim .07\,\Delta}}$ @ 5 kV; $\underline{\underline{S \sim .28\,\Delta}}$ @ 10 kV

⊛ B δx due to $T(x)$ change resulted from wire offset $\quad \delta x (x = R) \lesssim \frac{\Delta}{3}$!

A and B positively correlated

A+B (averaged) $\sim 0.3 \cdot \Delta$ @ 10 kV $\leftrightarrow$ 50 μm

$\sim 0.2\,\Delta$ @ 5 kV $\leftrightarrow$ 100 μm

$\Delta < 100 - 150\,\mu m$ @ 4 atm

$\Delta < 300 - 500\,\mu m$ @ 1 atm

Andrey Golutvin

Andrey Korytov

TTR - Tests

ORGANIZATION OF ANALYSIS OF TTR TESTS

(Andrey Golutvin / Andrey Korytov)

TASKS:

(i) OPERATE THE TTR TO DETERMINE THE SINGLE LAYER RESOLUTION OF THE CSC AND RDT PROTOTYPES

(ii) INVESTIGATE THE SIMULTANEOUS OPERATION OF THE RPC WITH THE OTHER TWO TECHNOLOGIES, ESPECIALLY THE RDT WHICH MAY NEED THE RPC FOR A TRIGGER. OF INTEREST IS THE NOISE SENSITIVITY OF THE CSC TO THE RPC NOISE — A RELEVANT ISSUE IF WE DECIDE TO BUILD A HYBRID MUON SYSTEM

The intent of having a common analysis group for all technology options is that cross comparisons can be made and a uniform set of standards applied to all the technology options

LIST OF PROTOTYPES TO BE TESTED

CSC:

BNL (0.5 × 0.5)
Dubna (1.5 × 1.2)
HU (1 × 0.5)
→ delivered at TTR

BNL-BU (2 × 0.7) → expected

BU (RD5 at CERN)

RDT:

Dubna (4 × 1)

MSU (4 × 1)

BOTH RDT PROTOTYPES HAVE DEMONSTRATED RESOLUTION < 100 μ

PRIORITIES OF TTR TESTS

① CSC

PRIMARY GOAL:

The required resolution (~75μ) for CSC has to be demonstrated for big prototype

Tentative schedule:

- The analysis of HU prototype is in progress.
- BNL (0.5 × 0.5) prototype → (96.3μ) K.Lau (this meeting)

  Now: tuning and calibration of electronics

  Next week: move to TTR

  Preliminary results are expected by ~ December, 15

- Dubna prototype (1.5 × 1.2)

  → The same schedule

Note: Dubna prototype has only 2 gaps

⟹ can be tested only in conjunction with other prototypes: RDT or CSC

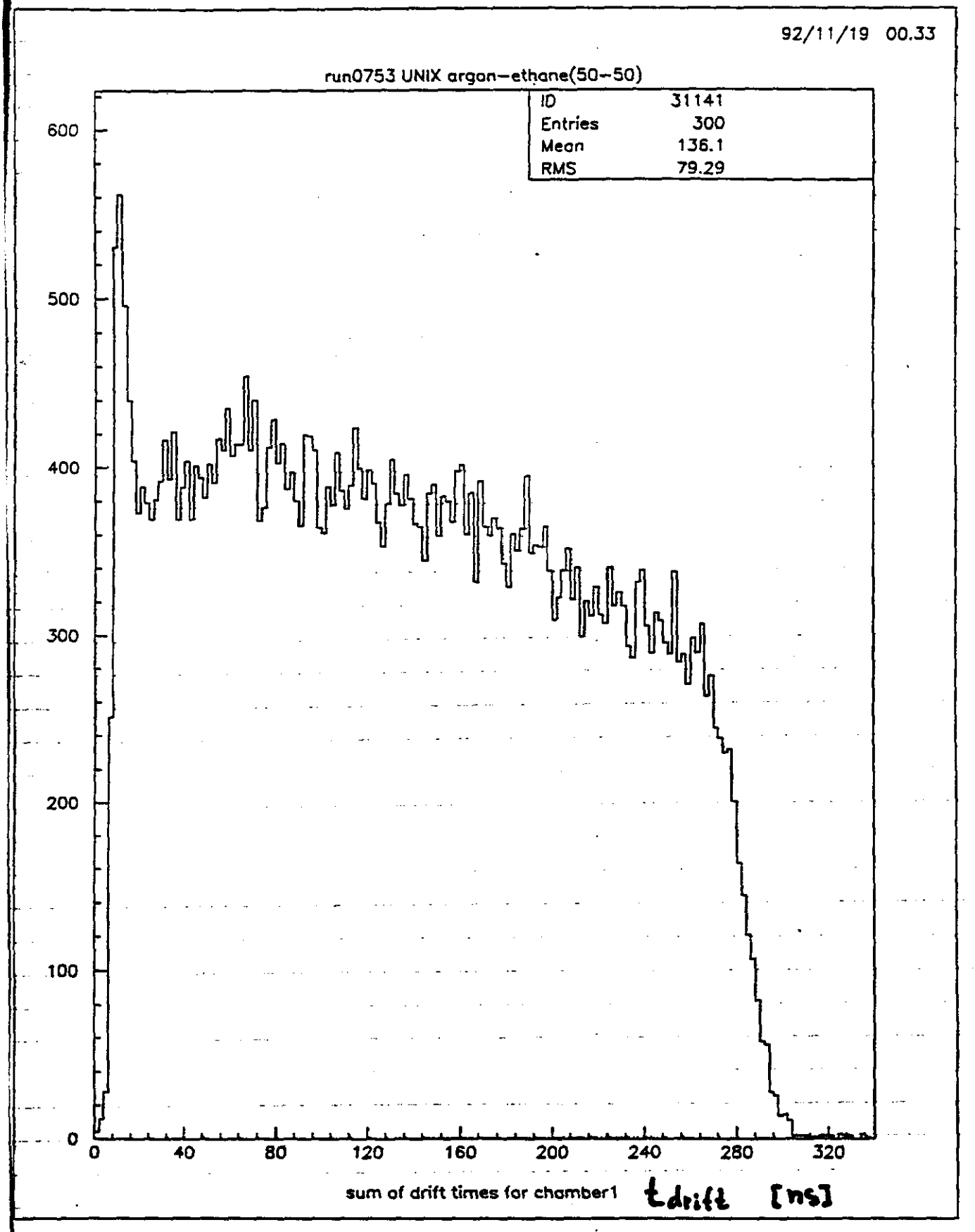
(2) RDT

Primary goal:

- TEST Dubna and MSU prototypes at higher pressures both in streamer and proportional modes

- Investigate the simultaneous operation of the RPC and RDT in proportional mode

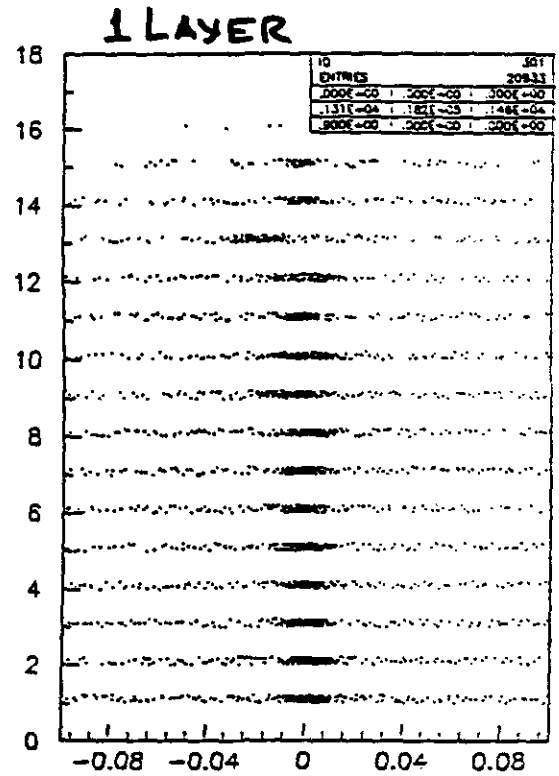
$(Ar-C_2H_6)$ 50/50


92/11/19 00.33
run0753 UNIX argon−ethane(50−50)
ID 31141
Entries 300
Mean 136.1
RMS 79.29
600
500
400
300
200
100
0
0
40
80
120
160
200
240
280
320
sum of drift times for chamber1
t_{drift} [ns]

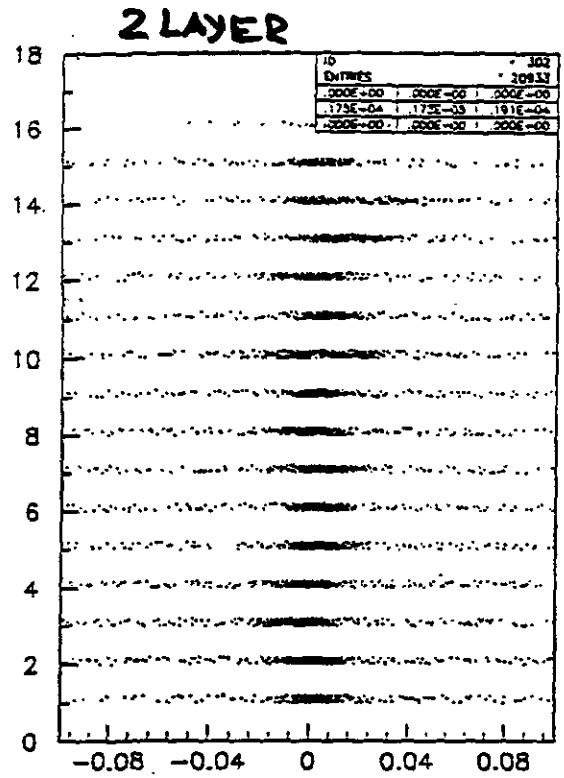
Ar-C_4H_{10} (25,

RESIDUALS vs TUBE NUMBER

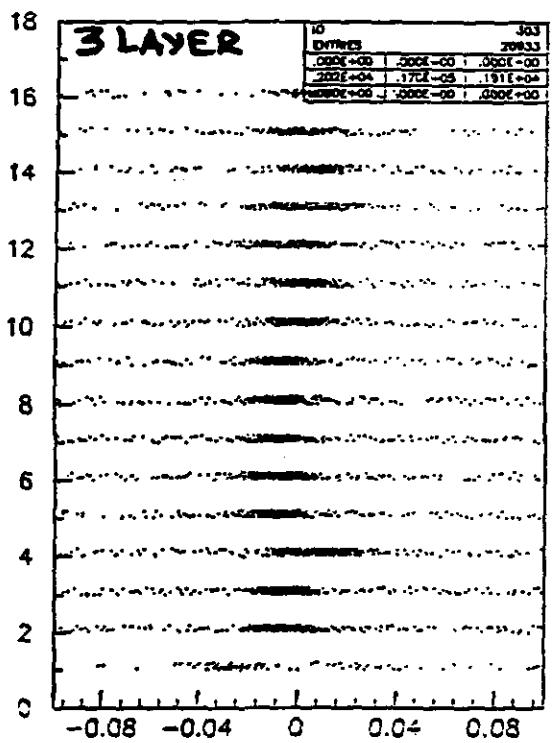
92/11/02 22.33



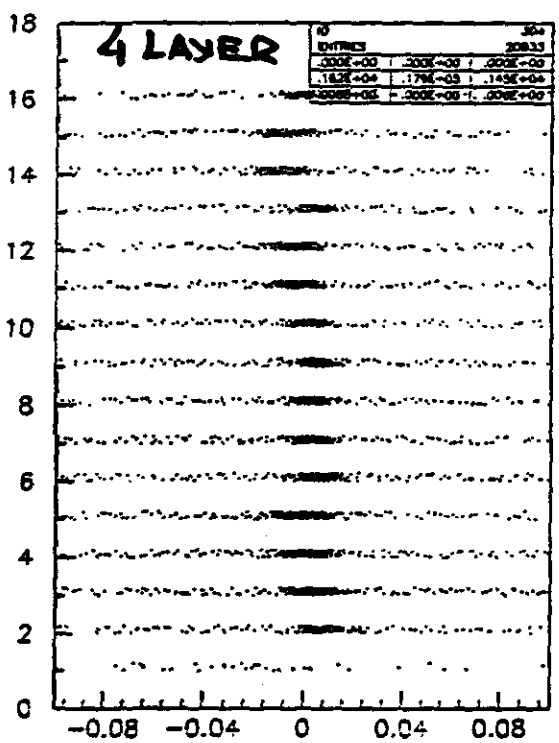
delta(Y) vs tube number for layer 1



delta(Y) vs tube number for layer 2



delta(Y) vs tube number for layer 3



delta(Y) vs tube number for layer 4

REQUEST FOR PEOPLE

SSC TTR group (including visitors)

Andrey Korytov (MIT)

Valeri Chernyatin (BNL)

Robert Miller (MSU)

Kwong Lau (HU)

The presence of these people at SSCL during TTR tests is very important for successful data analysis

Frank Taylor

R & D Fy 93 Short term

R&D Fy 93 Short term ≤ TDR

Period Oct., Nov., Dec, Jan., Feb.
5 mo.

Guide line from G. Sanders
$5m for 1 year ⇒ $\frac{5}{12} \times 5 = \$2.1m$

Task	1	ch. R&D	$580k
	2	ch. Testing	$207k
	3	Trigger	$60k
	4	Alignment	$200k
	5	Elec. Evaluation	($100k) {with elec. group}
	6	Simulations	$25k
	7	Indrustrialization & Layout of factory	$225k
	8	Engineering	$590k

Σ $1987k

FAX Monday
Nov. 23

617-253-1755