GEM TN-92-183

EM Calorimeter Meeting - University of New York at Stony Brook

September 17, 1992

Abstract:

Agenda, attendees, and presentations of the GEM EM Calorimeter Meeting held at the University of New York at Stony Brook on September 17, 1992. Agenda items are: Optimization of the GEM EM Noble Liquid Calorimeter; Discussion of RD3 Preshower Approach; Parallel Plate Preradiator Solution; Fine Strips in the Accordion Structure; Specification to Pointing in the EM Calorimeter; Pi-zero Rejection Using Shape Analysis Only; DRDC Preshower Detector Design; and Discussion and Work Assignments.

Summary of LKr Optimization Task Force Meeting 9/17/92 (Stony Brook)

Goals of the task force are to optimize energy resolution, pi-zero and multiphoton rejection, and photon pointing.

David Lissauer suggested that the present accordion be optimized by
1) Changing the average thickness of lead as a funtion of theta.
2) Developing a massless gap on the front of the accordion.
3) Increasing transverse segmentation.
4) Increasing longitudinal segmentation.

He pointed out that a preradiator will present special problems:
1) Poor resolution if outside the cryostat.
2) Reading out 250K channels if inside the cryostat.

Veljko Radeka summarized the large RD3 R&D effort on a fine grain preshower detector inside the cryostat. There is plan to develop electronics appropriate to reading out large numbers of channels in the cryostat. The position readout would use a large number of low quality channels, while the energy measurement would use ganging and a smaller number of high quality channels.

Paul Mockett presented the parallel plate calorimeter and showed some data as well as Monte Carlo results for pion rejection.

Misha Leltchouk presented options for putting position readout (strips) in the accordion.

Assignments:

1. Committee to insure uniform generation of Monte Carlo events:

   Hong Ma (BNL), Chairman
   Kostya Schmakov (Oak Ridge)
   Sasha Vanyashin (SSC)
   Jon Eisenberg (U Washington)

2. Optimization of Accordion

   David Lissauer, Howard Gordon, Misha Leltchouk, Hong Ma, Jean-Yves Hostachy, Kostya Schmakov, Yuri Kamyshkov, Michael Seman

3. Multiplexing in the cryostat

   Veljko Radeka, Hong Ma

4. Strips in the accordion

   Misha Leltchouk

5. Preradiator

   Yuri Kamyshkov, Misha Leltchouk, Kostya Schmakov

6. Parallel Plate Option

   Paul Mockett

Hong Ma is organizing a meeting at BNL on Sept. 22-24 to coordinate the Monte Carlo simulation efforts. Michael Seman's code for the projective accordion will be the basis for the optimization efforts.

Notes take by Bob McCarthy (edited by Howard Gordon)

GEM EM Calorimeter Meeting on Thursday, Sept. 17, 1992

ANNOUNCEMENT

We have been asked to optimize the liquid krypton EM calorimeter for GEM for the following:

1) Optimization of the energy resolution
2) Rejection of multiphotons due to pi0 or other multiphoton states
3) Optimization of photon pointing

I have asked Bob McCarthy from Stony Brook to organize a task force to study and recommend a solution for GEM. Bob has extensive hands on experience with liquid ionization calorimeters. There will be a preliminary meeting on Thursday, Sept. 17 at 9 AM in Room D118, Graduate Physics Building, SUNY - Stony Brook, Stony Brook, New York. A preliminary agenda:

I. Outline of the goals - D. Lissauer
II. Review of the RD3 Solution - V. Radeka
III. Review of the parallel plate solution - P. Mockett
IV. Fine strips in the accordion structure - M. Leltchouk
V. Discussion and work assignments

Howard

AGENDA

I. Optimization of the GEM EM Noble Liquid Calorimeter - D. Lissauer
II. Discussion of RD3 Preshower Approach - V. Radeka
III. Parallel Plate Preradiator Solution - P. Mockett
IV. Fine strips in the accordion structure - M. Leltchouk
VI. Specification to pointing in the EM calorimeter - A.Vanyashin
VII. Pi-zero rejection using shape analysis only - K.Shmakov
VIII. DRDC Preshower Detector Design - Yu Kamyshkov
IX. Discussion and work assignments

GEM EM Calorimeter Meeting

September 17 1992

Stony Brook

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Presentation by:

D. Lissauer

Optimization of
The GEM EM Noble Liquid Calorimeter

I. Physics Requirements:

- Energy Resolution: $\delta E/\mathrm{E} = 6.0\%/\sqrt{E} \oplus 0.4\%$.
- γ/Jet separation, γ/π^0 separation.
- Pointing: Mass resolution at high luminosity.

II. Optimization Tools:

- Transverse segmentation.
- Longitudinal segmentation.
- Preradiator.

D. Lissauer
17, Sept, 1992.

Preradiator Options.

I. Preradiators incorporated in the existing structure *(Misha Leltchuk et. al.)*

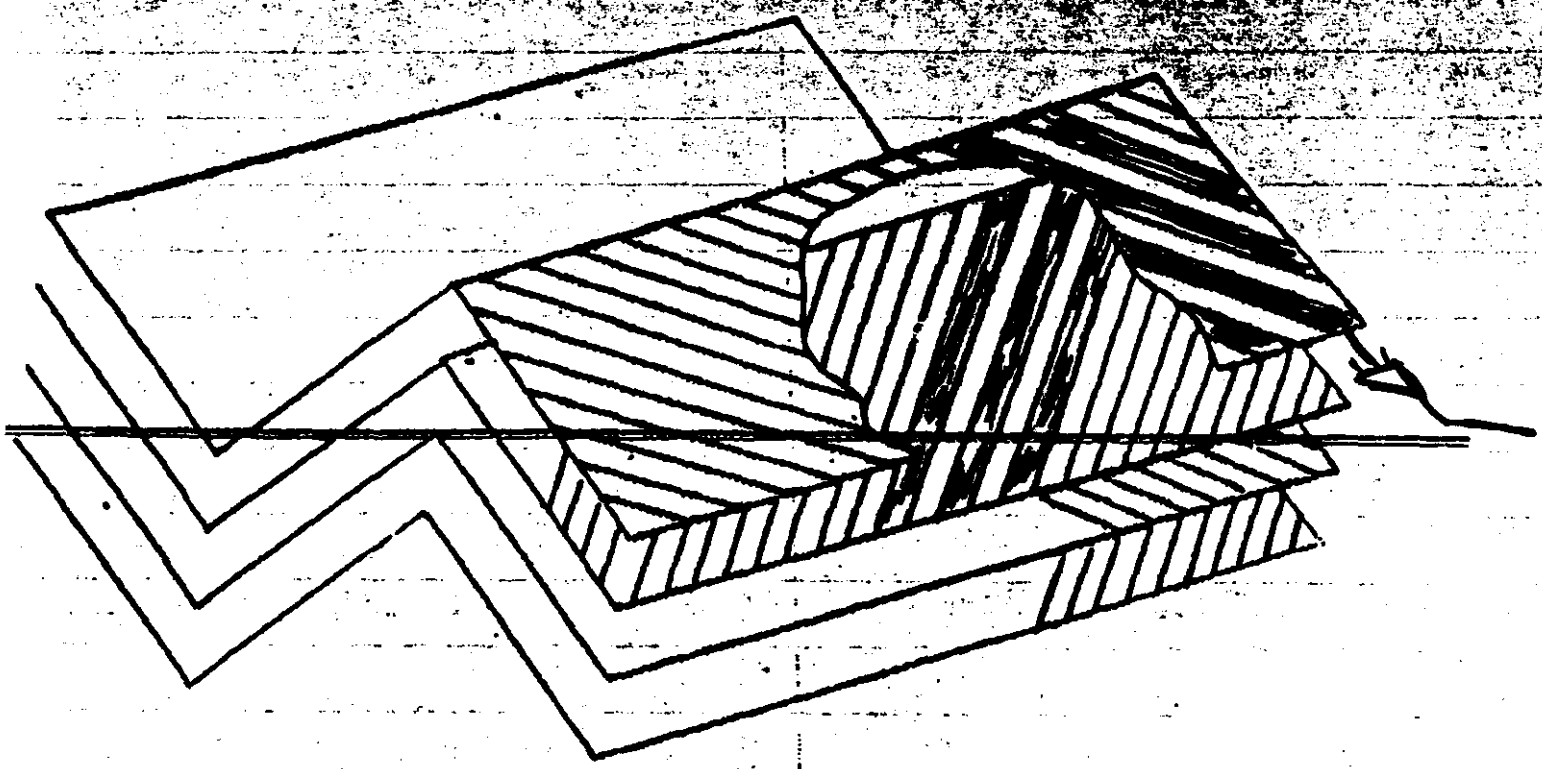
- 1-2 mm strips (See Figure)

Advantages:

- No new mechanical structure.

Disadvantages:

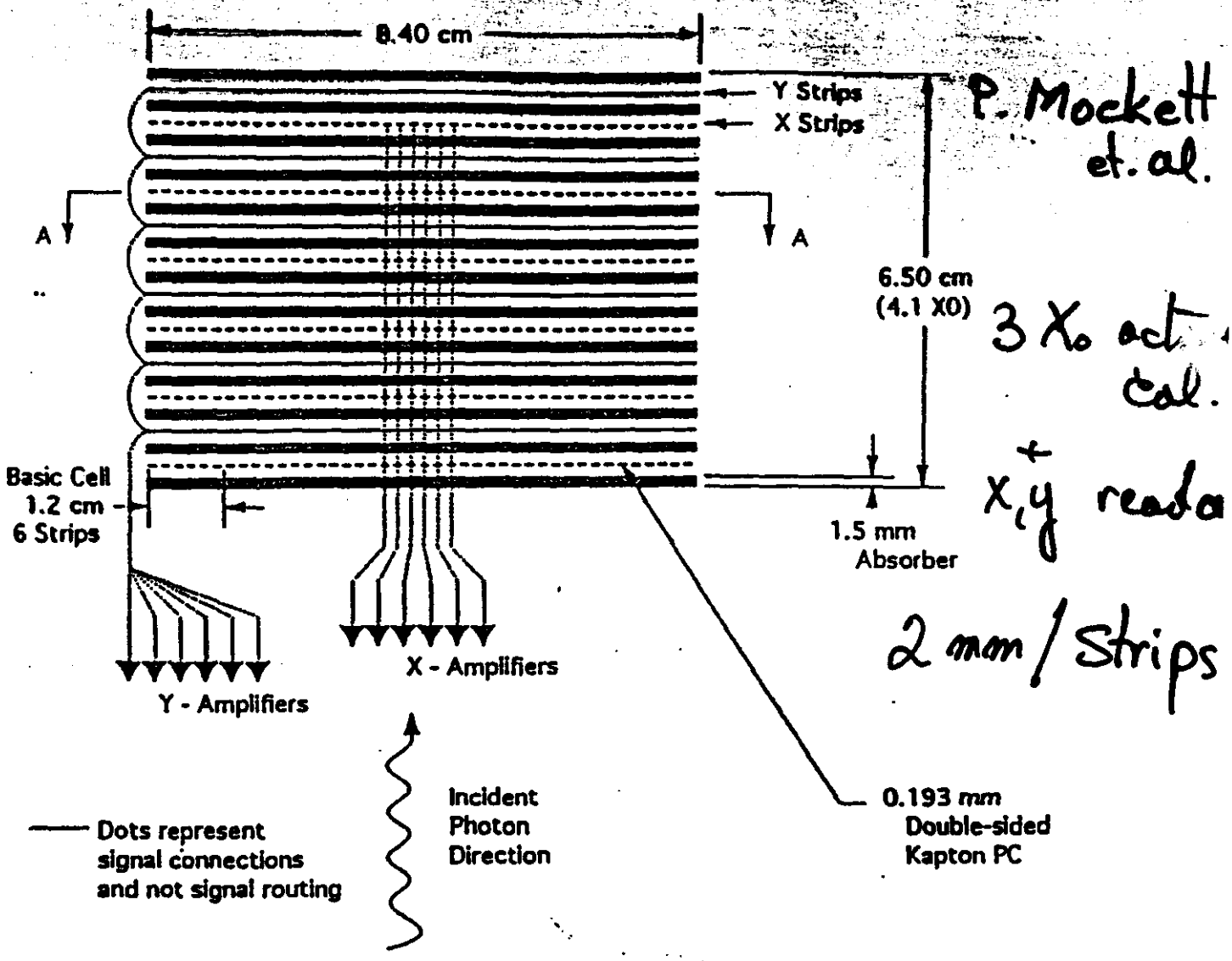
- Signal / Noise: $\rightarrow$ 200-300K Channels
- Feedthrough
- Multiplex analog information inside. A new order of complexity. R&D.
- New electronics must be radiation hard. (Near shower max)
- Calibration: need to calibrate the energy to better than 1% (increase in the constant term).

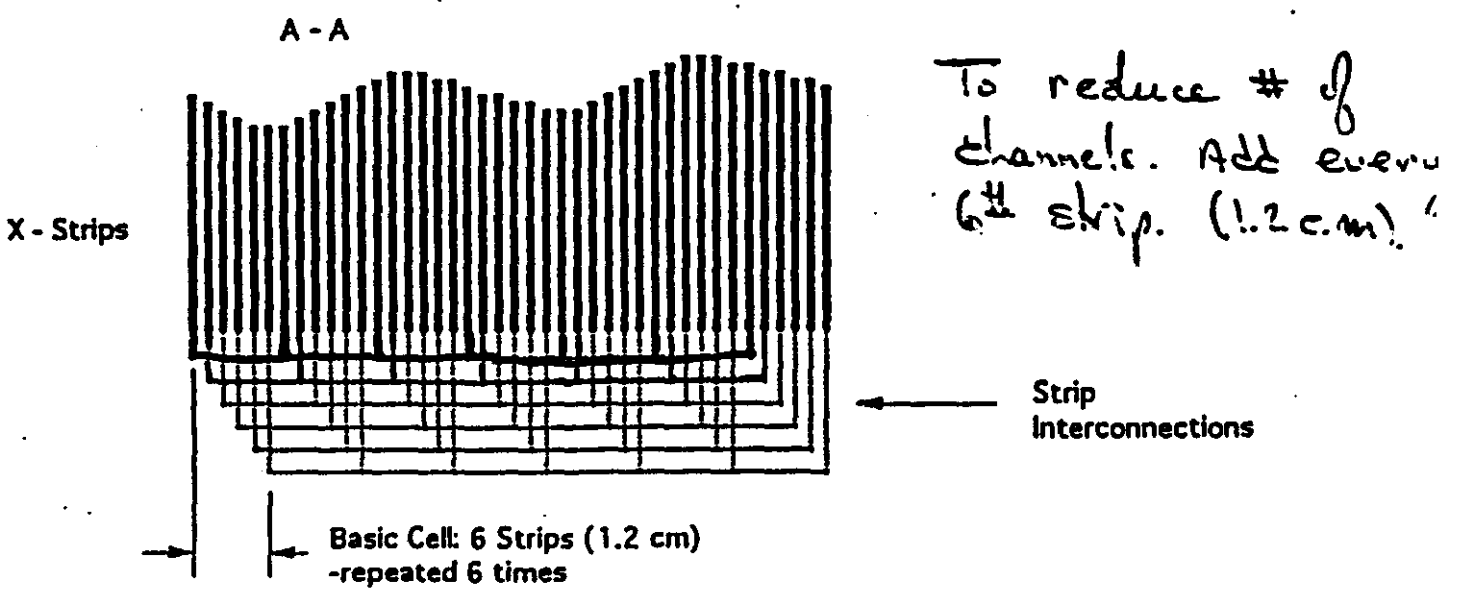


Lellchuk et. al.

U, V strips. (R - strips)

1-2 mm width.


8.40 cm
Y Strips
X Strips
P. Mockett et. al.
A
A
6.50 cm
(4.1 X0)
3 X0 act. cal.
Basic Cell
1.2 cm
6 Strips
1.5 mm
Absorber
x, y readout
2 mm / Strips
Y - Amplifiers
X - Amplifiers
Incident
Photon
Direction
0.193 mm
Double-sided
Kapton PC
Dots represent
signal connections
and not signal routing


A - A
X - Strips
To reduce # of channels. Add every 6th strip. (1.2 cm).
Strip
Interconnections
Basic Cell: 6 Strips (1.2 cm)
-repeated 6 times

II. Preradiators with Additional Structure

2. RD3 - Venetian blind

There is a fundamental difference between GEM and ATLAS (Eagle/Ascot). They have a 10% energy resolution target. Infront of the calorimeter (L.A) they have a magnet + thicker walls due to the larger radius.i.e They have nearly $3X_0$ of dead material already. Combine the functions of massless gap and preradiator. (NOT our case)

GEM radius is nearly a factor of 2 smaller than ATLAS. To get the same π^0 rejection need smaller electrode elements by the same factor.(Unfortunately π^0 opening angles are universal).

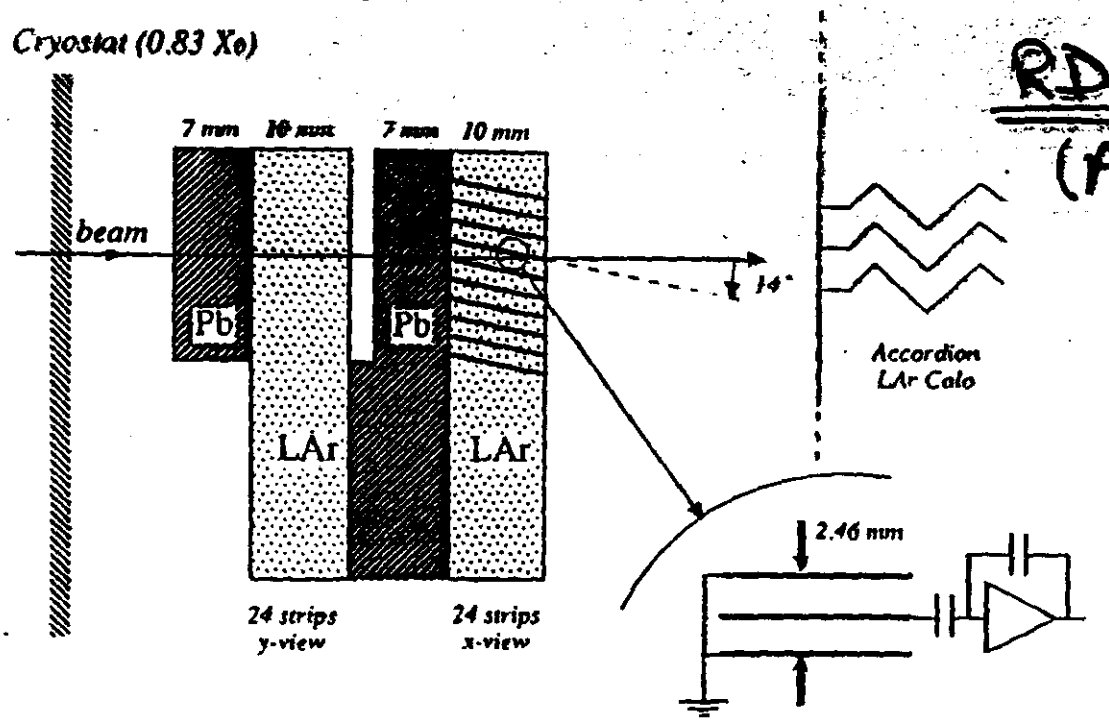
In order to sample at shower max an active calorimeter is needed in front of the venetian blind. Or suffer additional degradation of the energy resolution. (not acceptable).

Advantages:

- Venitian blind construction have lower capacitance , signal to noise is improved.
- Higher signal to noise means a possible reduction in the number of channels.
- Simple mechanical construction.

Disadvantages:

RD3: (ATLAS)



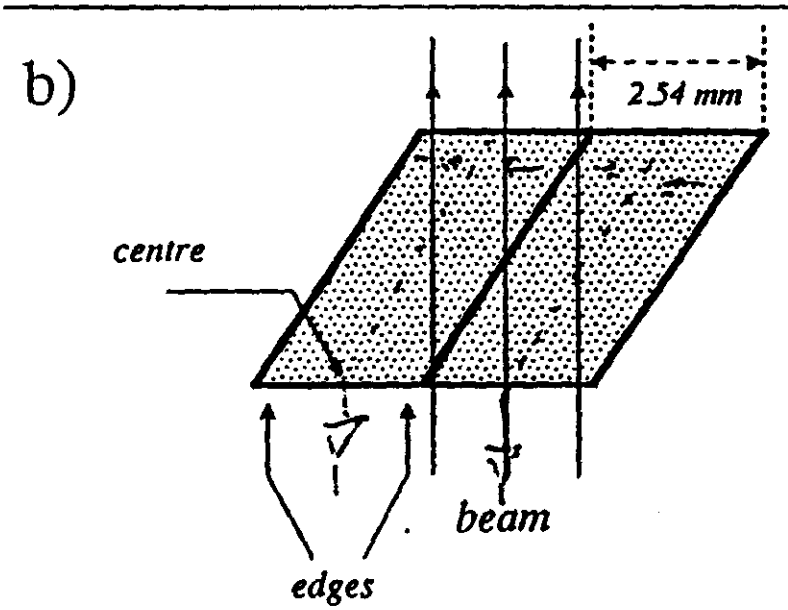


Figure 1: a) Schematic layout (not on scale) of the small LAr preshower prototype; b) cell geometry.

RD3: a) Massless gap. ($3X_0$ dead)

b) Pre radiator.

- Still needs a $3X_0$ calorimeter in front. (separate structure)
- Dead material at Shower max.
- Electronics: Same as Mockett *et al.* (250K channels)

Jim Brau et al

III. Solution outside the Cryostat ([redacted])

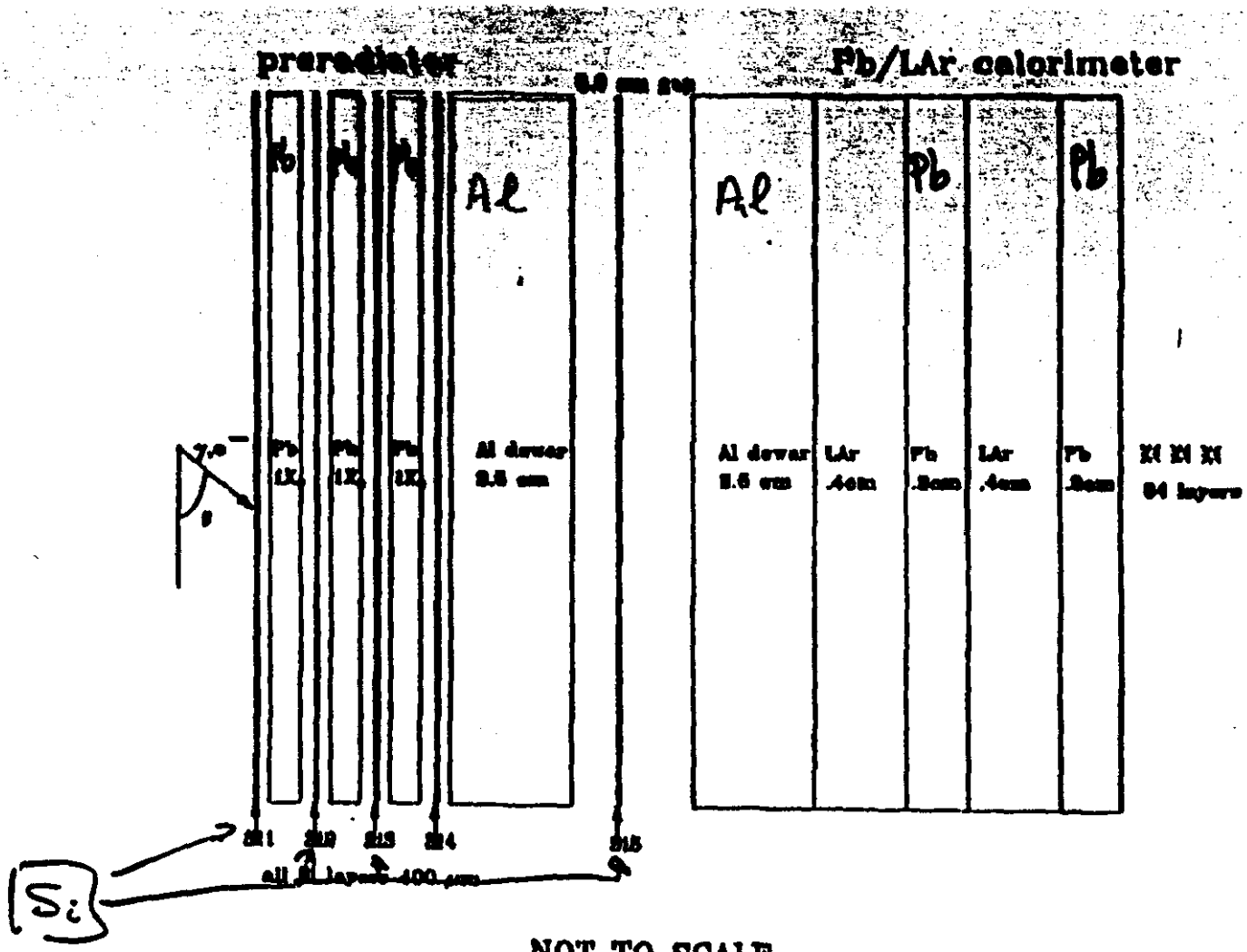
See Figure.

Advantages:

- Outside the cryostat.
- Decouple the cal. constraction from the preradiator.
- Can be staged.
- electronic channels are outside, multiplexing can be done with similar readout as the chambers and/ or Si detectors.

Disadvantages:

- Need to sample the first three radiation length.
- Large number of channels.
- Energy resolution might be compatible with 9% but not better.(dead material near shower max.)



NOT TO SCALE

Figure 1. EGS4 geometry

J. Brau et al.

<u>Conclusions</u>:

1. You need to meas. E before cal + in 3λ to get back resolution.

2. 1 mm strips.

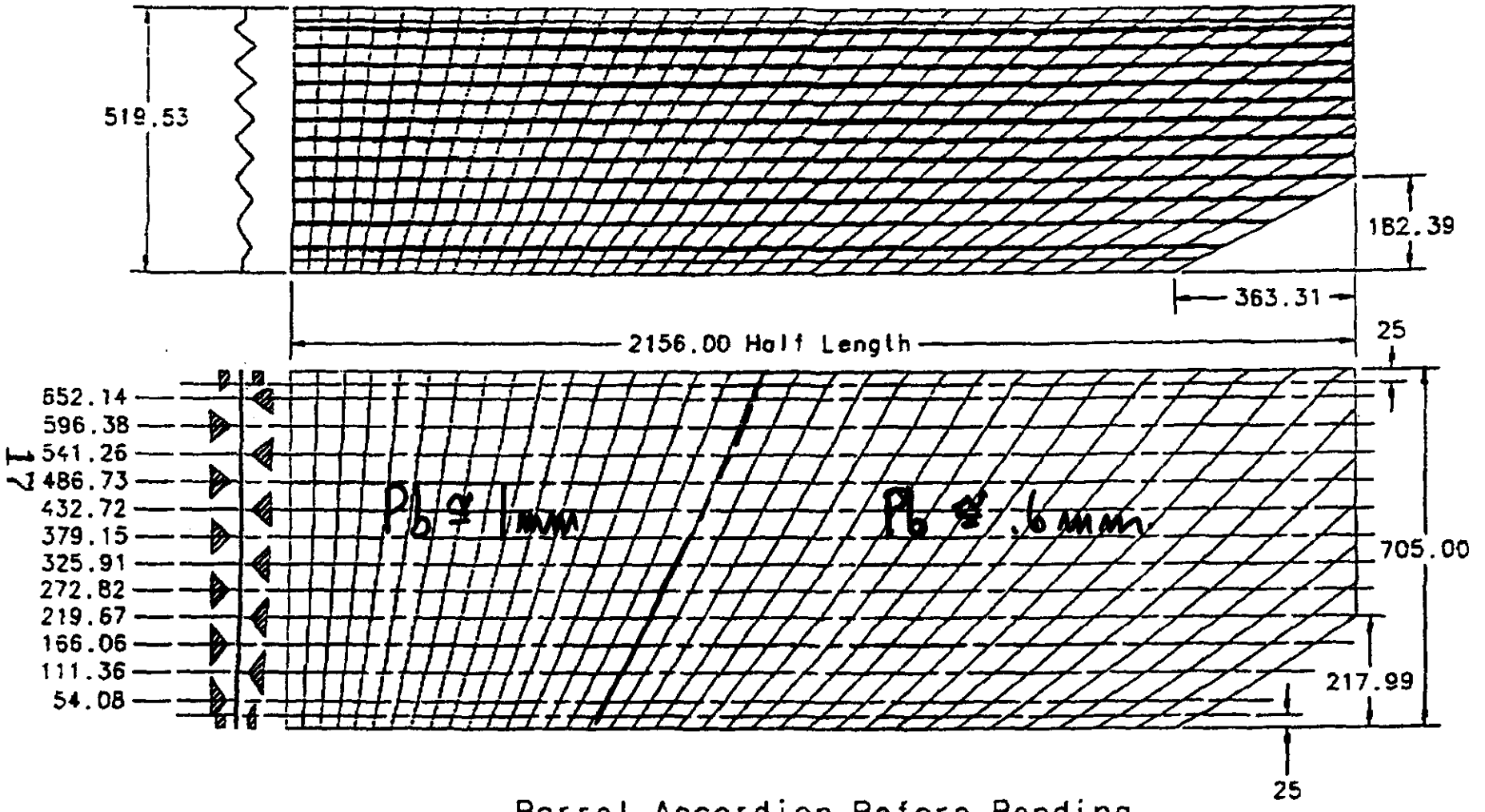
Optimization with present Design

In this meeting we are discussing only the optimization that have to do with the questions relating to the function of preradiators. There is a long list of optimizations that has to be done!!!!!

WE NEED TIME !!!!!!!

STARTING NOW !!!!!!

Barrel Accordion After Bending



Barrel Accordion Before Bending

1. Optimize: $\rho(z)$ Pb

200 absorber and 200 sensing plates
with .04 X .04 Segmentation

Optimization with present Design

1. Optimize the Pb density as a function of η. (Fig)

   Advantages:

   – Improve Energy resolution. item Improve Pointing.
   – No additional cost.

   Note:

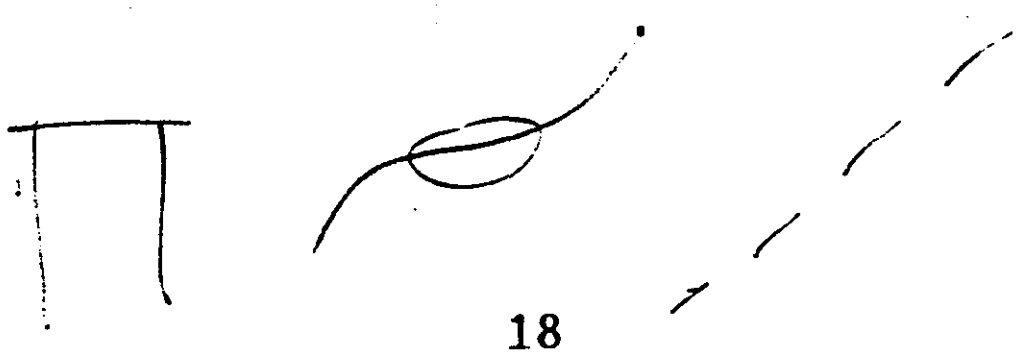
   Already now we have lower density calorimeter than RD3. Reducing the density has two main advantages:

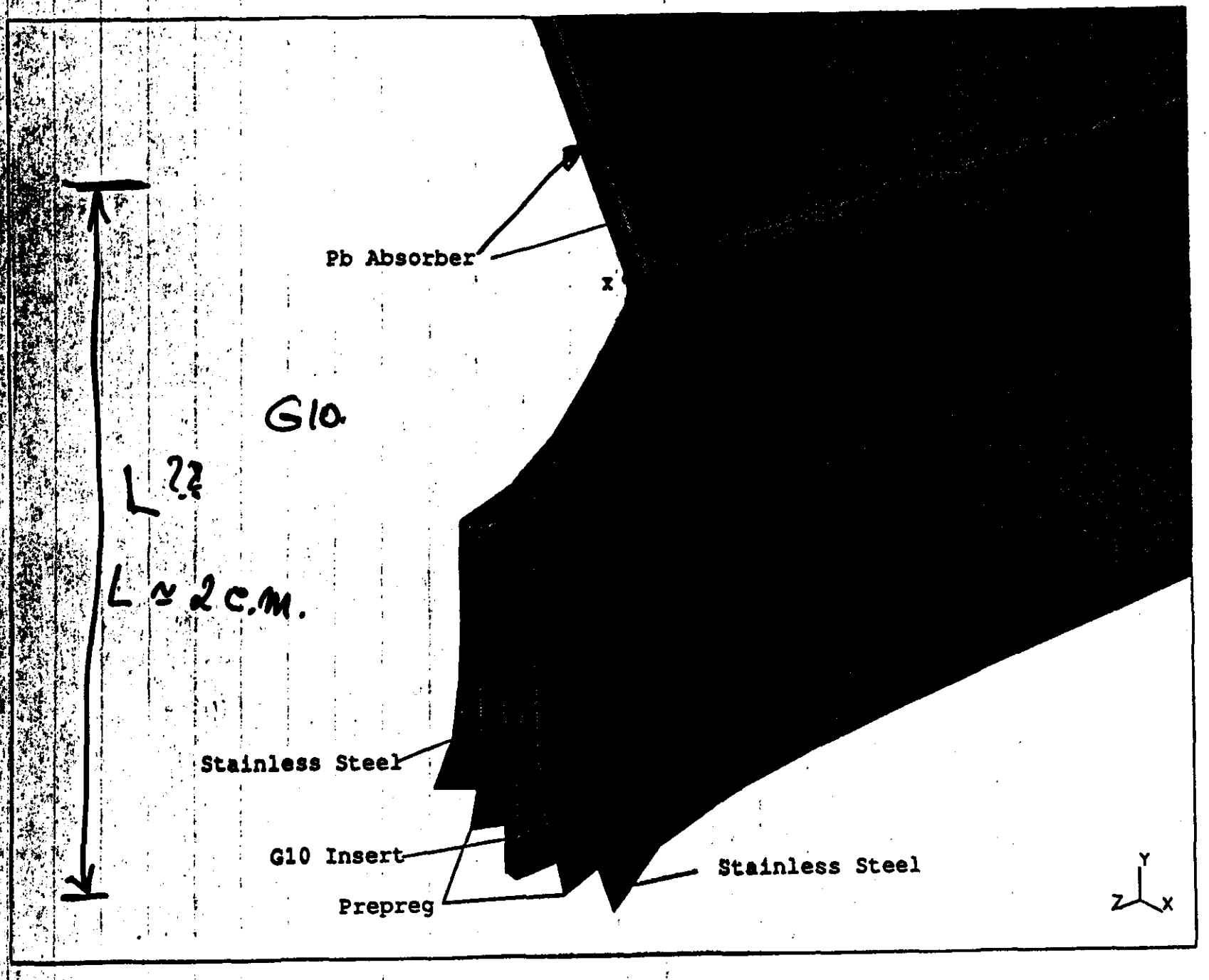
   – **Position resolution become better due to shower spread in the transverse direction.**
   – **Shower become longer and the lever arm between the two measured points is larger resulting in a better angular resolution.**

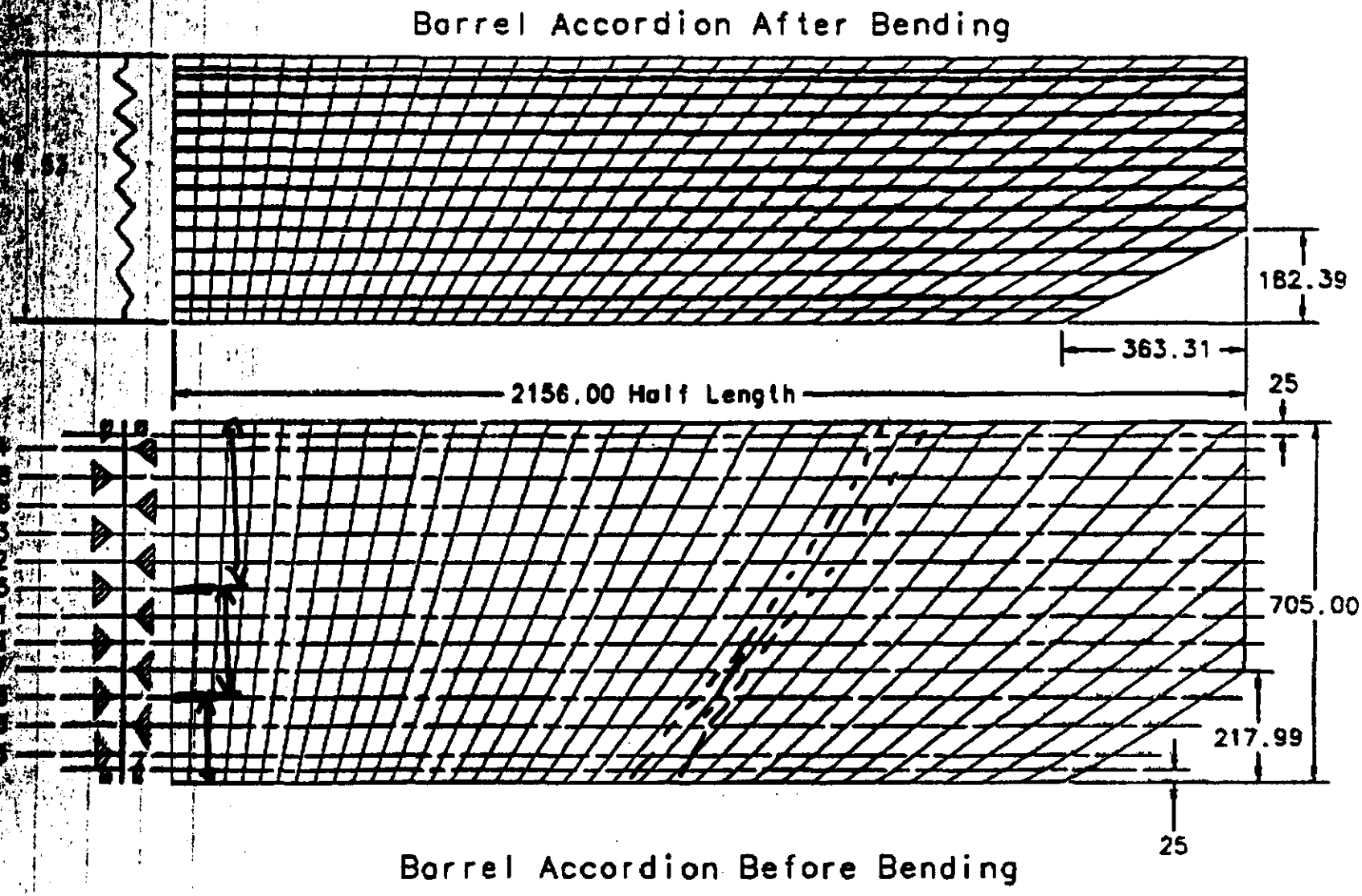
2. **Optimize the passive massless gap in the absorber**

   Advantage:

   – **Improve energy resolution.**




Pb Absorber
x
G10
L ??
L ≈ 2 c.m.
Stainless Steel
G10 Insert
Prepreg
Stainless Steel
Y
Z
X



200 absorber and 200 sensing plates
with .04 X .04 Segmentation

2. Optimize granularity

$\Delta\eta \times \Delta\varphi$: .2x.32 ?? better pointing.

3. Increase the transverse segmentation.

   e.g: We can have asymetric $\delta\eta$, $\delta\phi$ segmentation. Increasing the segmentation in η and thus the position resolution, pointing as well as multiphoton rejection due to better shower shape analysis.

   Advantages:

   – Better position resolution.

   – Better γ to multi-γ separation (better shower shape).

4. Longitudinal segmentation.

In the case of two longitudinal sections we need to optimize the ratio of front and back, taking into account both energy resolution and pointing resolution.

In the same structure one can add a third readout.

Advantages:

– Better multi-γ to single-γ rejection (longitudinal shower shape).

– Better pointing.

Disadvantages:

– Additional $\approx 30K$ channels of electronics.

gem

γeμ

Presentation by:

V. Radeka

DISCUSSION OF RD-3 PRESHOWER APPROACH

V. Radeka

17 Sept. 92

21

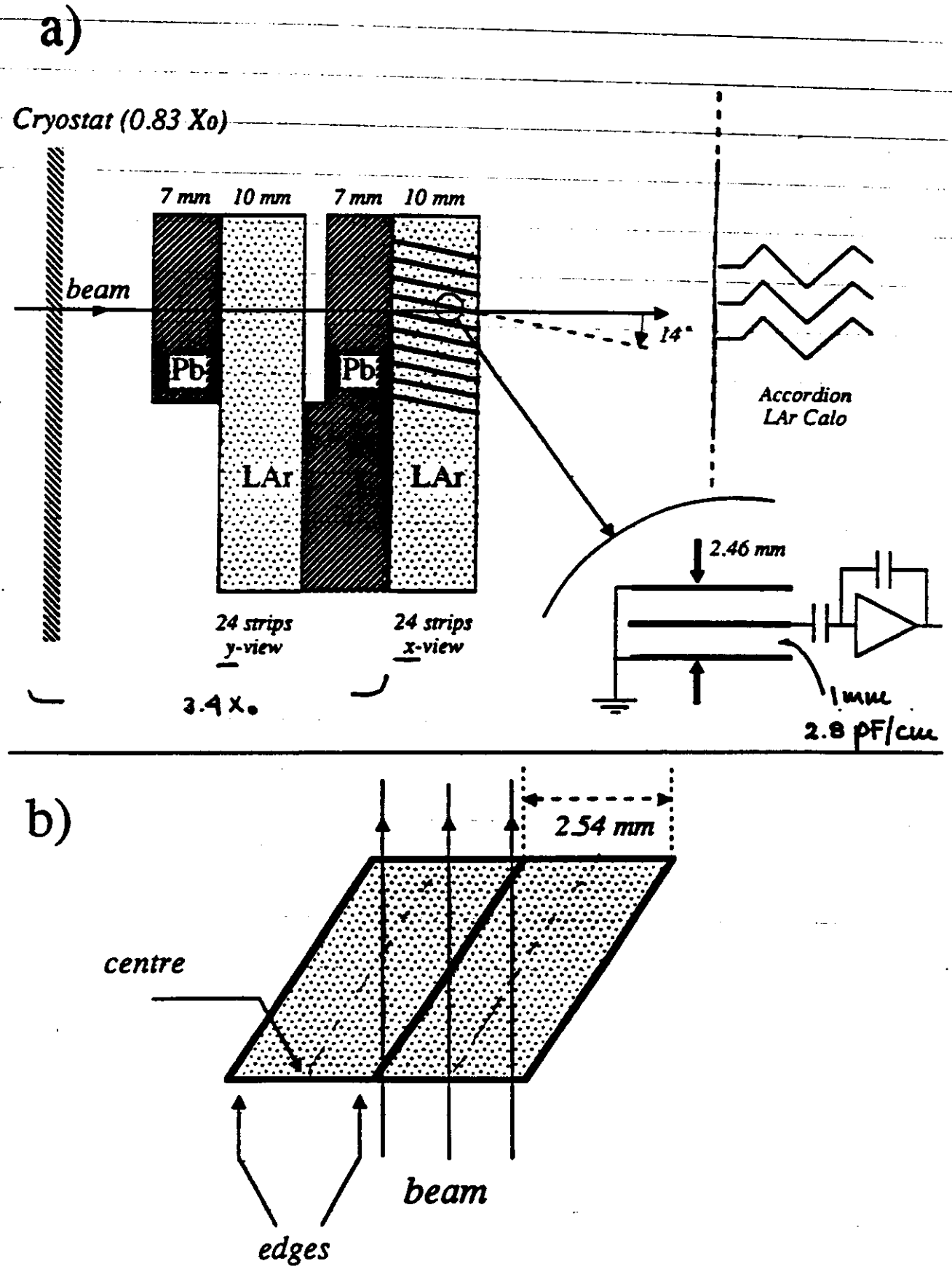
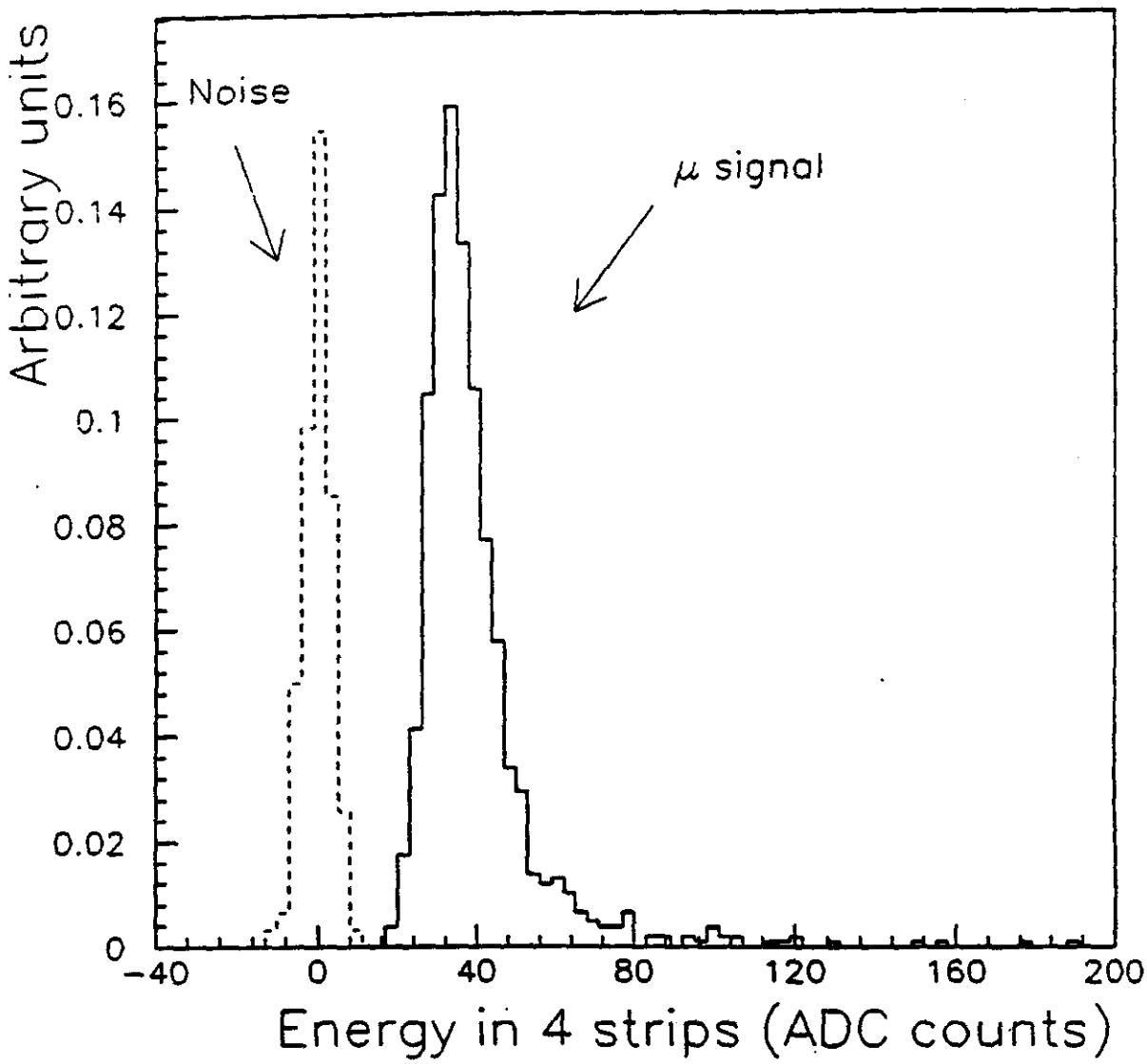


Figure 1: a) Schematic layout (not on scale) of the small LAr preshower prototype; b) cell geometry.



2 cells

σ_{el} $\approx 1.2\times10^3$ noise

4×10^4 e

1.6×10^4 e in 10 nsec

$S/N \approx 9$

Figure 2: Energy spectrum reconstructed in the preshower for 180 GeV muons. The dashed line is the distribution of the electronic noise.

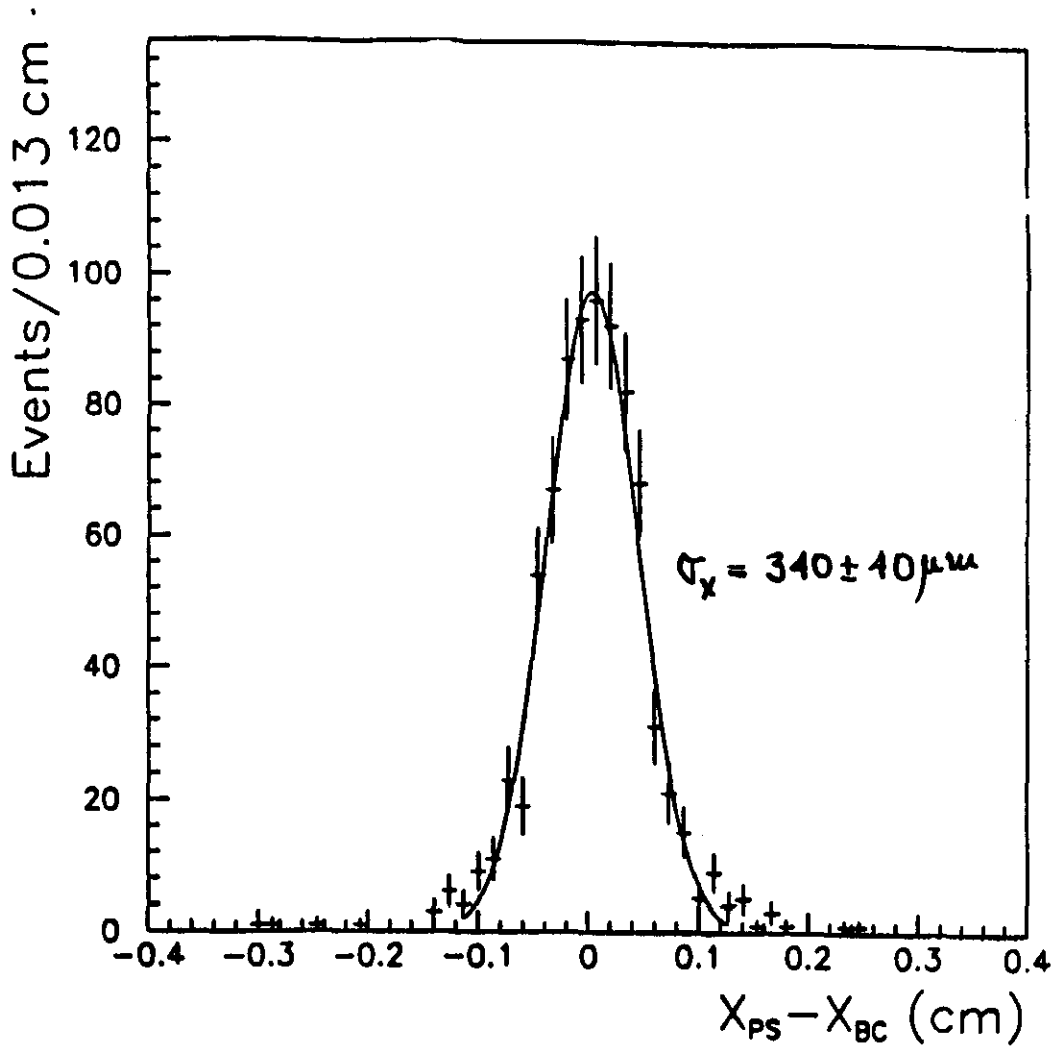


FIG. 4

μ position resolution

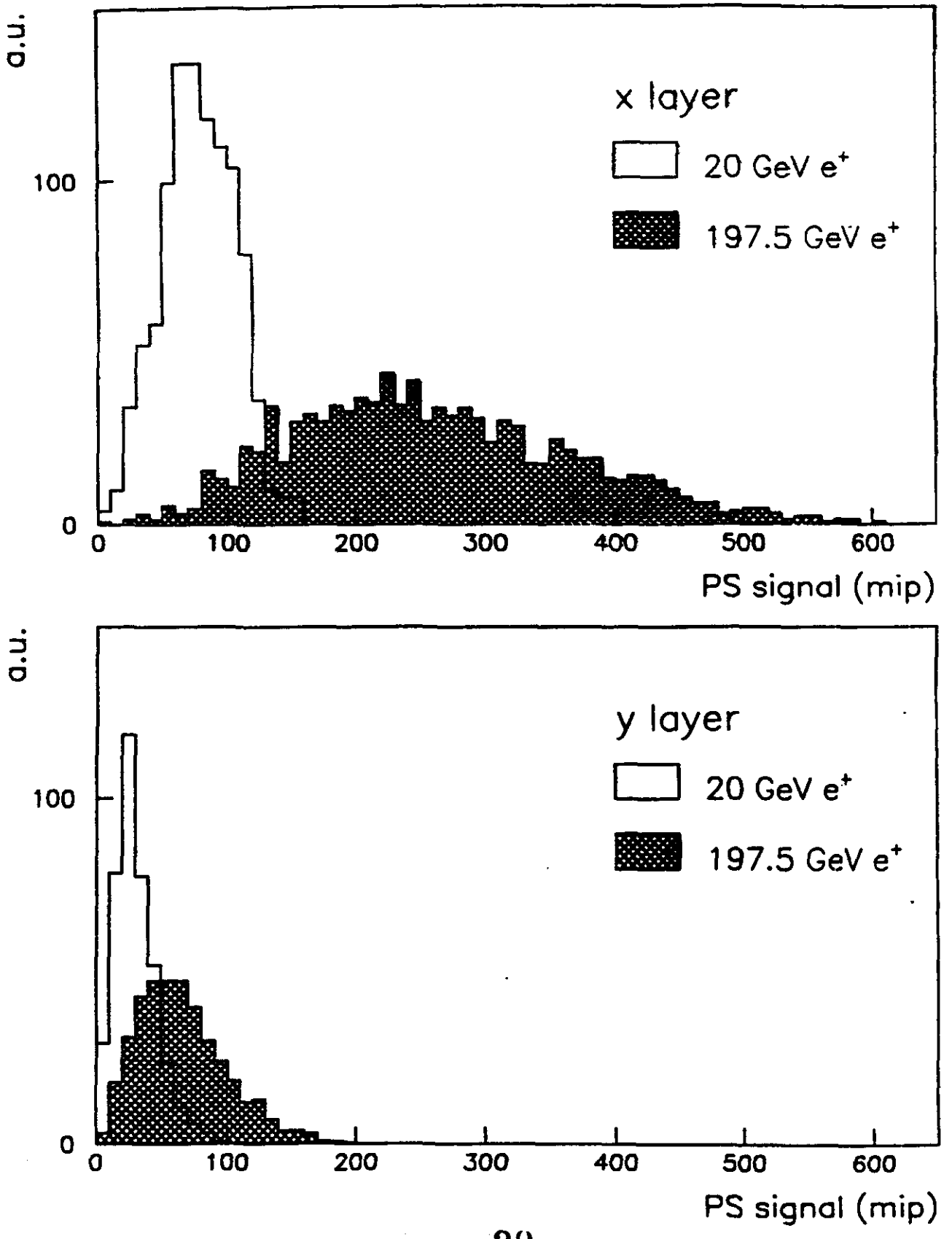
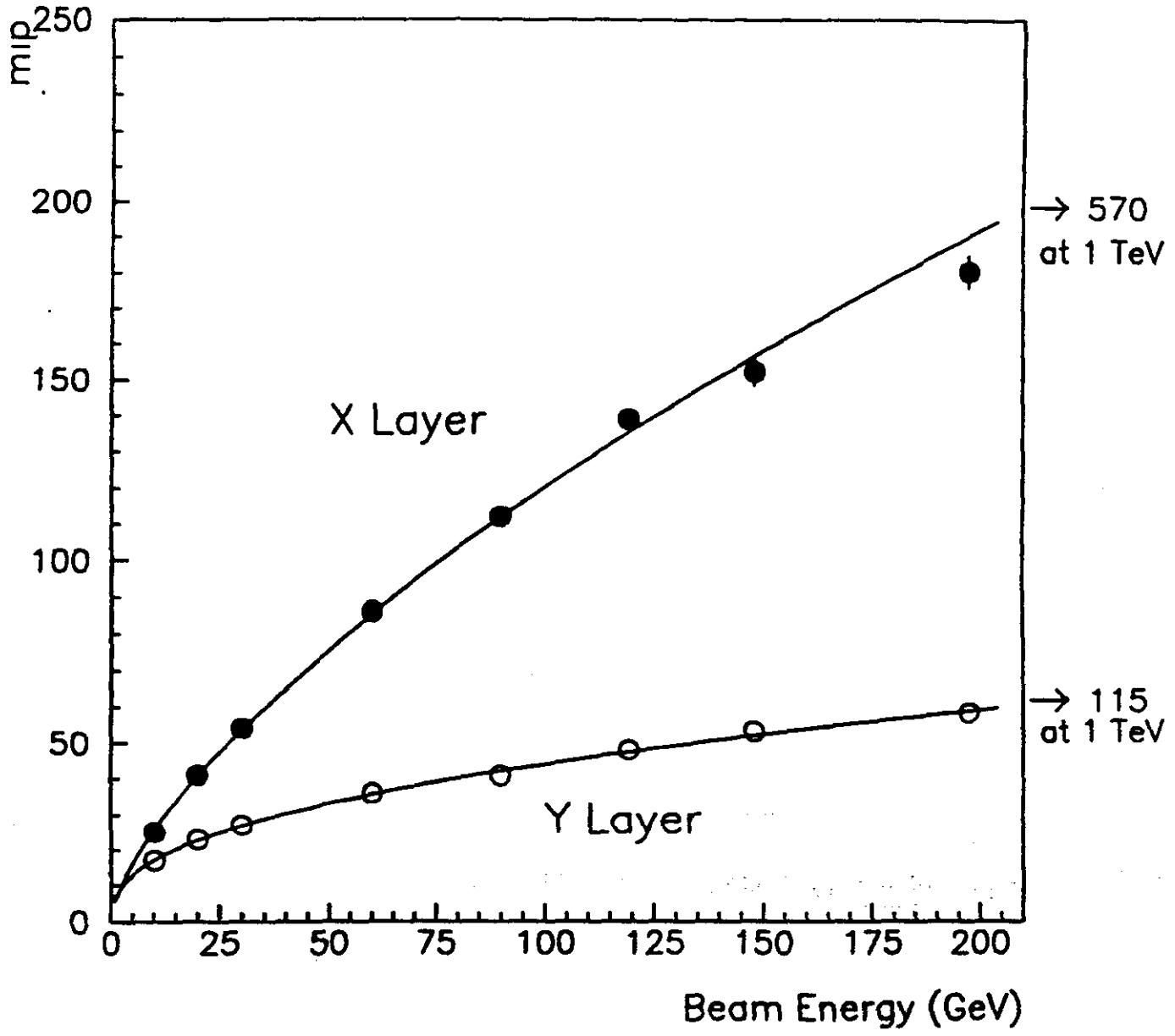

a.u.
x layer
20 GeV e+
197.5 GeV e+
100
0
0
100
200
300
400
500
600
PS signal (mip)
a.u.
y layer
20 GeV e+
197.5 GeV e+
100
0
0
100
200
300
400
500
600
PS signal (mip)

Fig. 6



Signal in the most energetic channel,
(95% electron efficiency)

Fig. 8

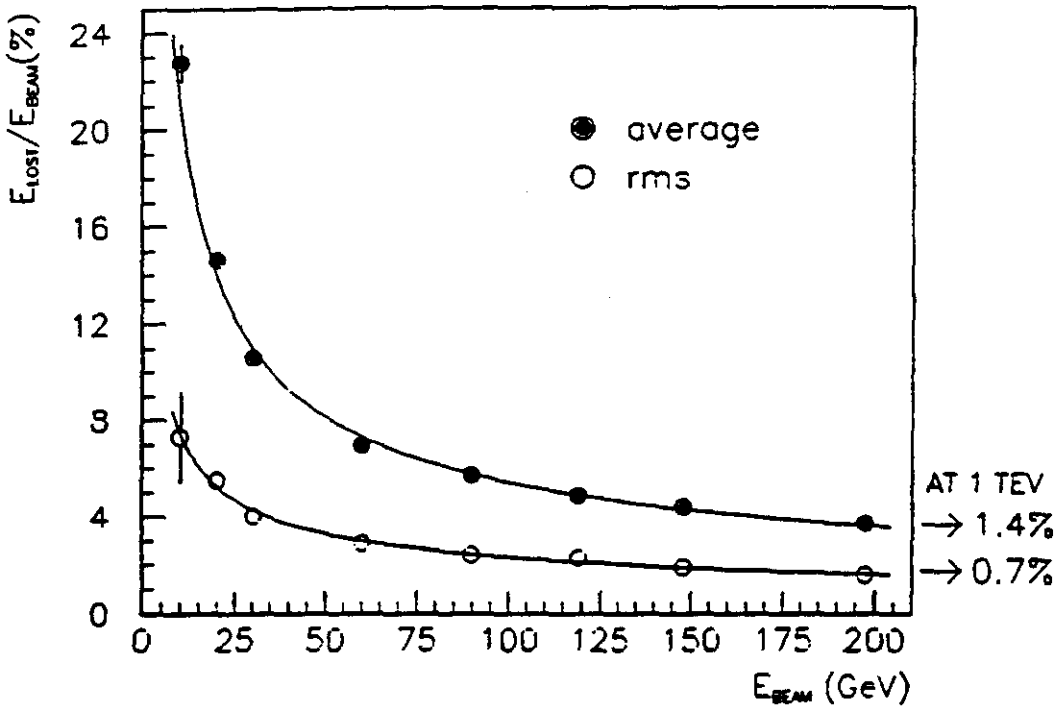


Figure 3: Average (black circles) and rms (open circles) fraction of energy lost in the material upstream of the calorimeter as a function of the incident electron beam energy. The extrapolation to 1 TeV is also indicated.

$\approx 3.8\ X_0$

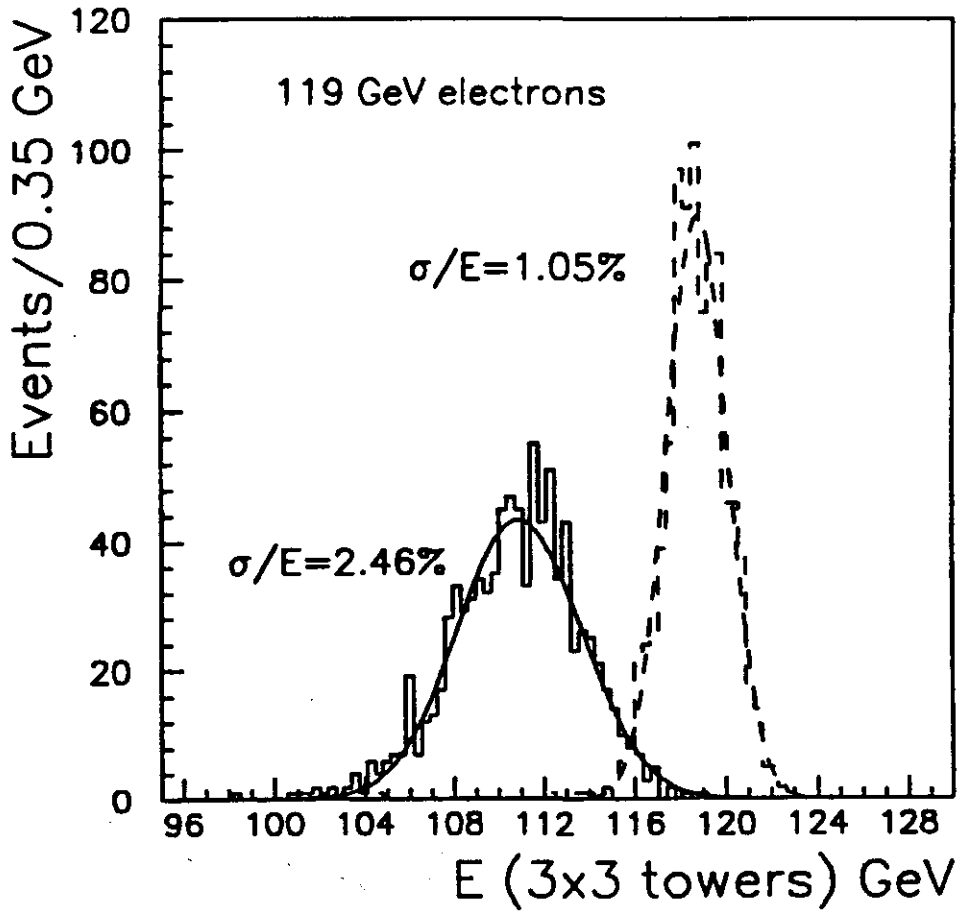

119 GeV electrons
σ/E=1.05%
σ/E=2.46%
Events/0.35 GeV
E (3x3 towers) GeV
0
20
40
60
80
100
120
96
100
104
108
112
116
120
124
128

Fig.10

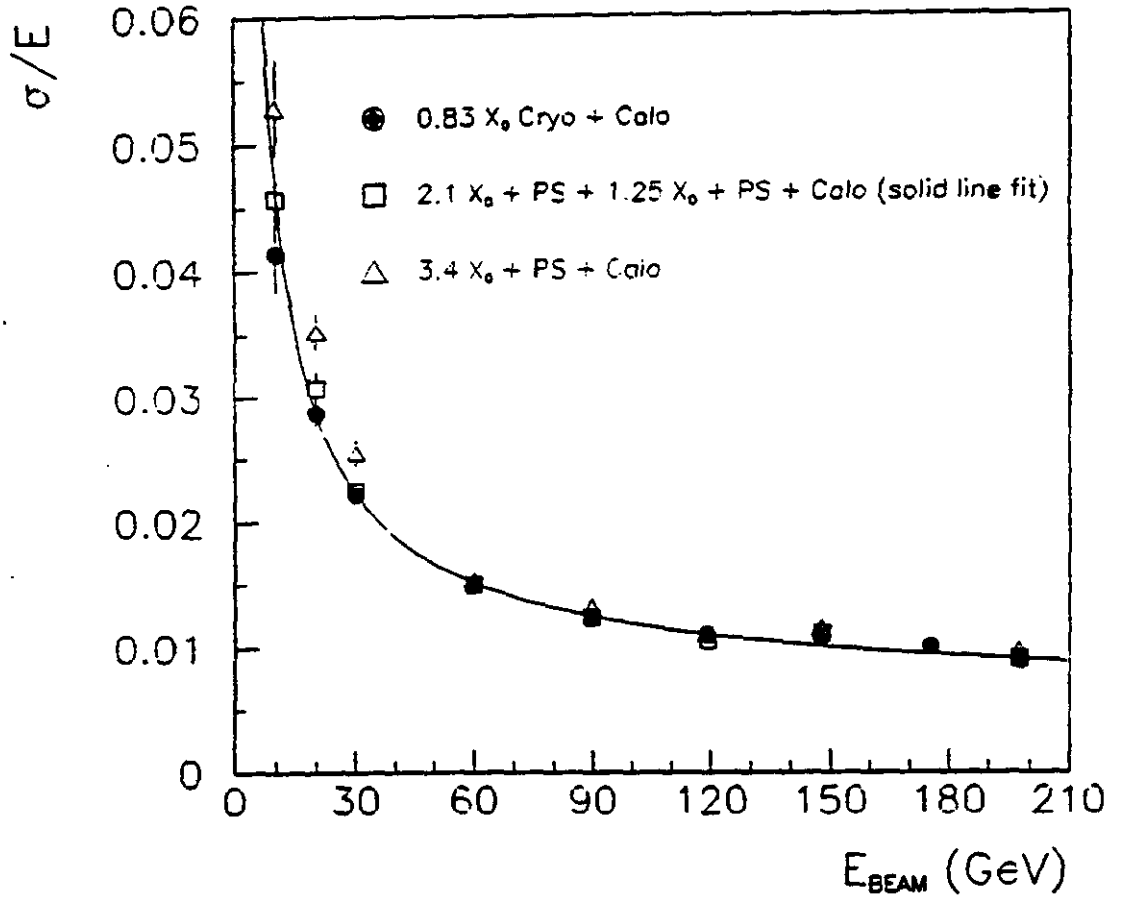


Figure 4: Energy resolution of the Accordion calorimeter as a function of the incident electron beam energy. Black symbols: region not covered by the preshower prototype. White symbols: region behind the preshower when both (squares) or only the second (triangles) preshower layer are used to recover the lost energy.

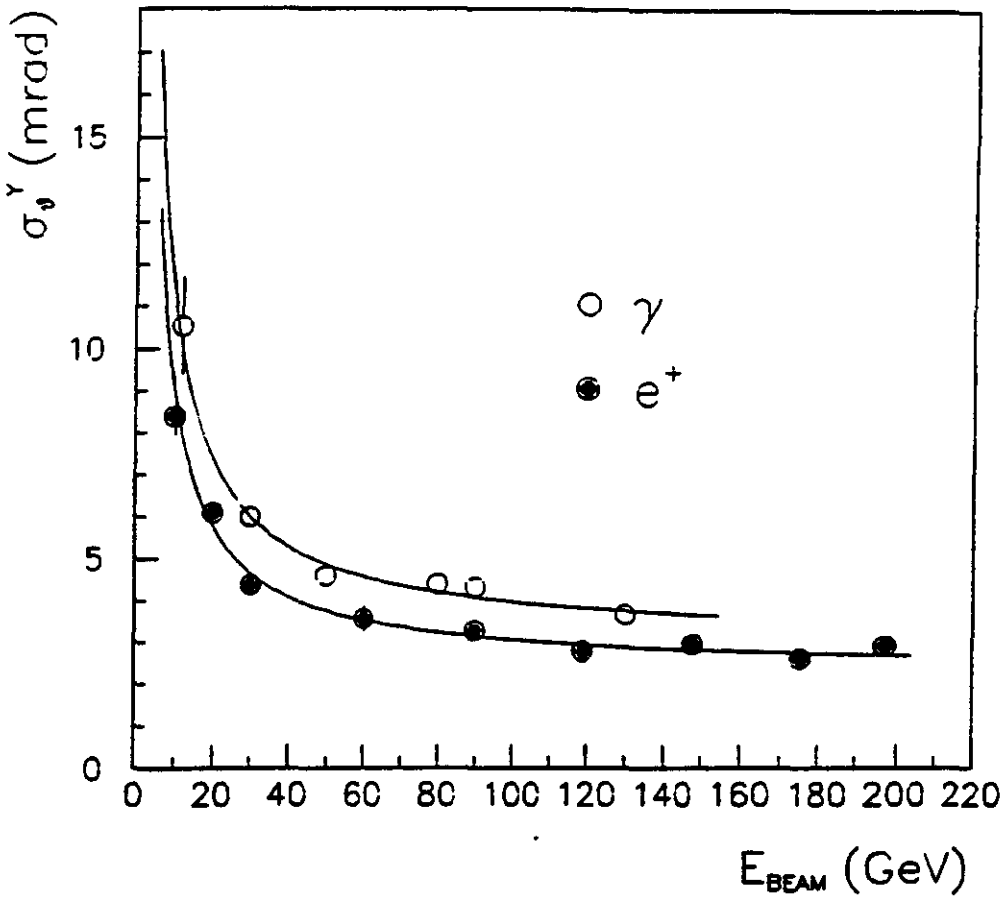
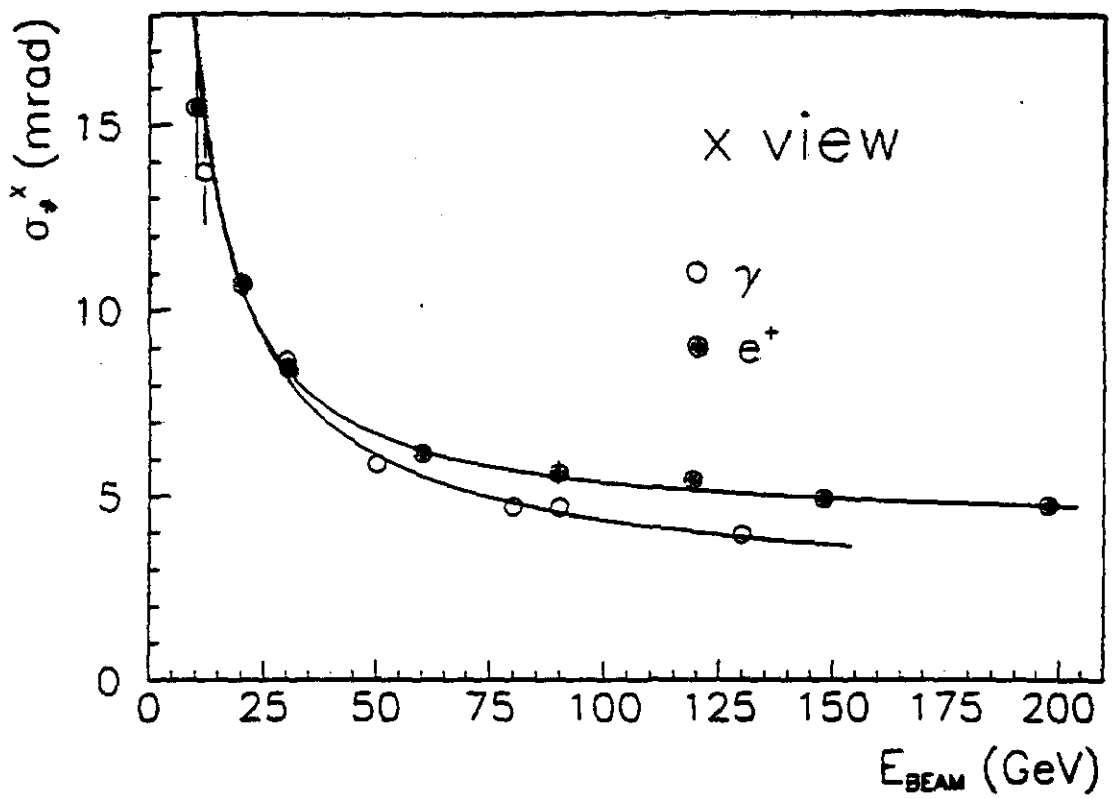


Figure 7: Angular resolution of the combined preshower–calorimeter system in the y direction as a function of the beam energy for electrons (black circles) and photons (open circles); only the first sampling of the Accordion (12.5 X_0) has been used for this measurement.


x view
γ
e+
σφx (mrad)
0
5
10
15
0
25
50
75
100
125
150
175
200
EBEAM (GeV)

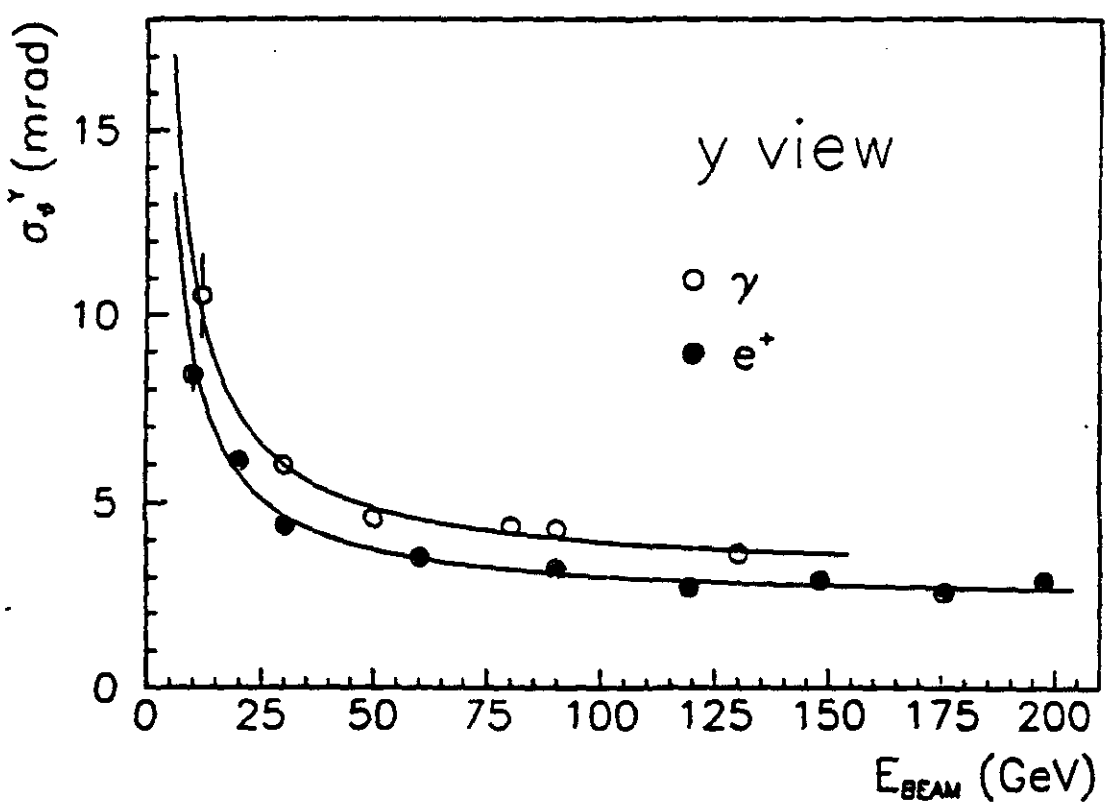
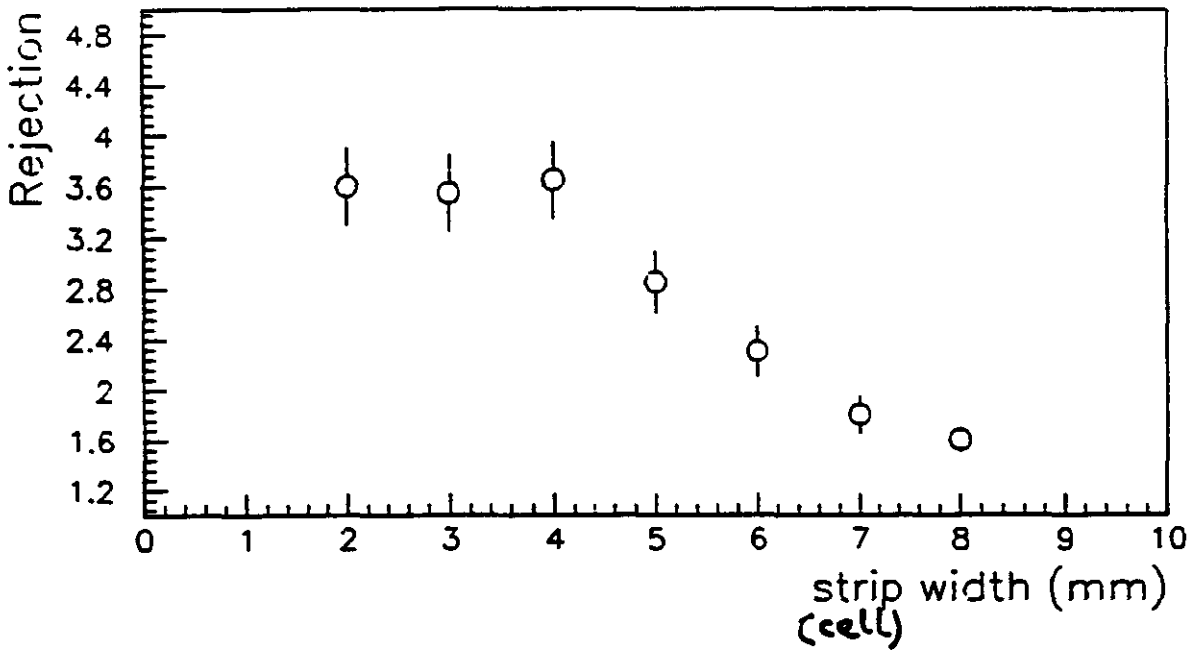

y view
γ
e+
σφy (mrad)
0
5
10
15
0
25
50
75
100
125
150
175
200
EBEAM (GeV)

FIG. 17



50 GeV π^0 at 1.4 m , min. separation ≈ 7 mm

0.85 m ≈ 4 mm

Figure 10: Rejection factor against 50 Gev π^0's at η=0 as a function of the strip width. Conclusion: cell size ≤ 3 mm at 1.4 m

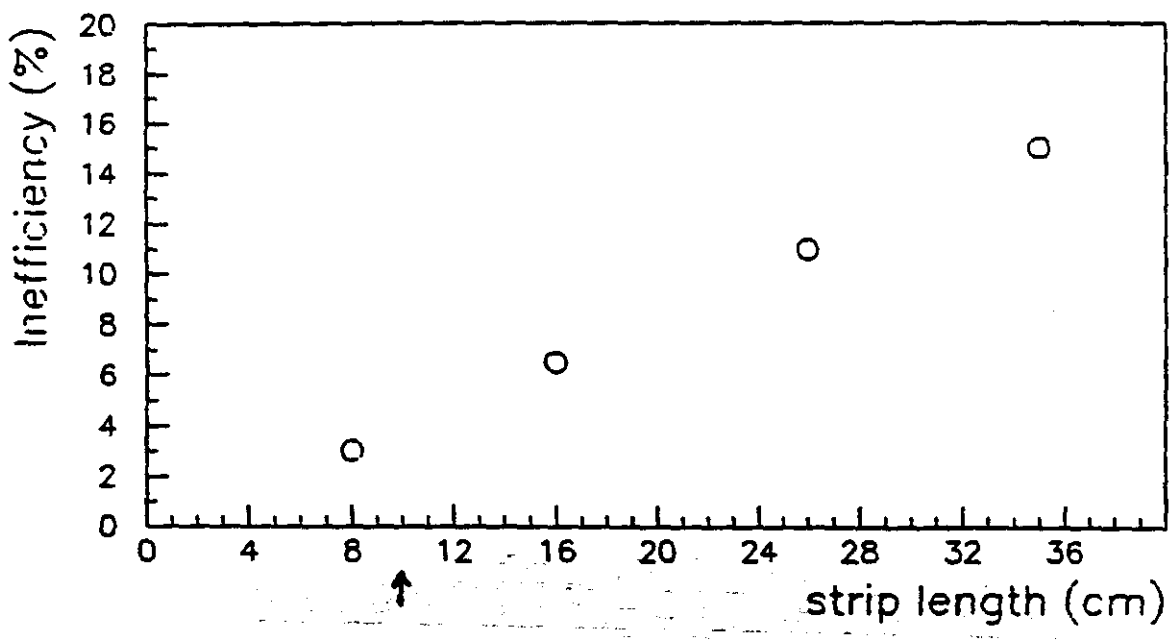
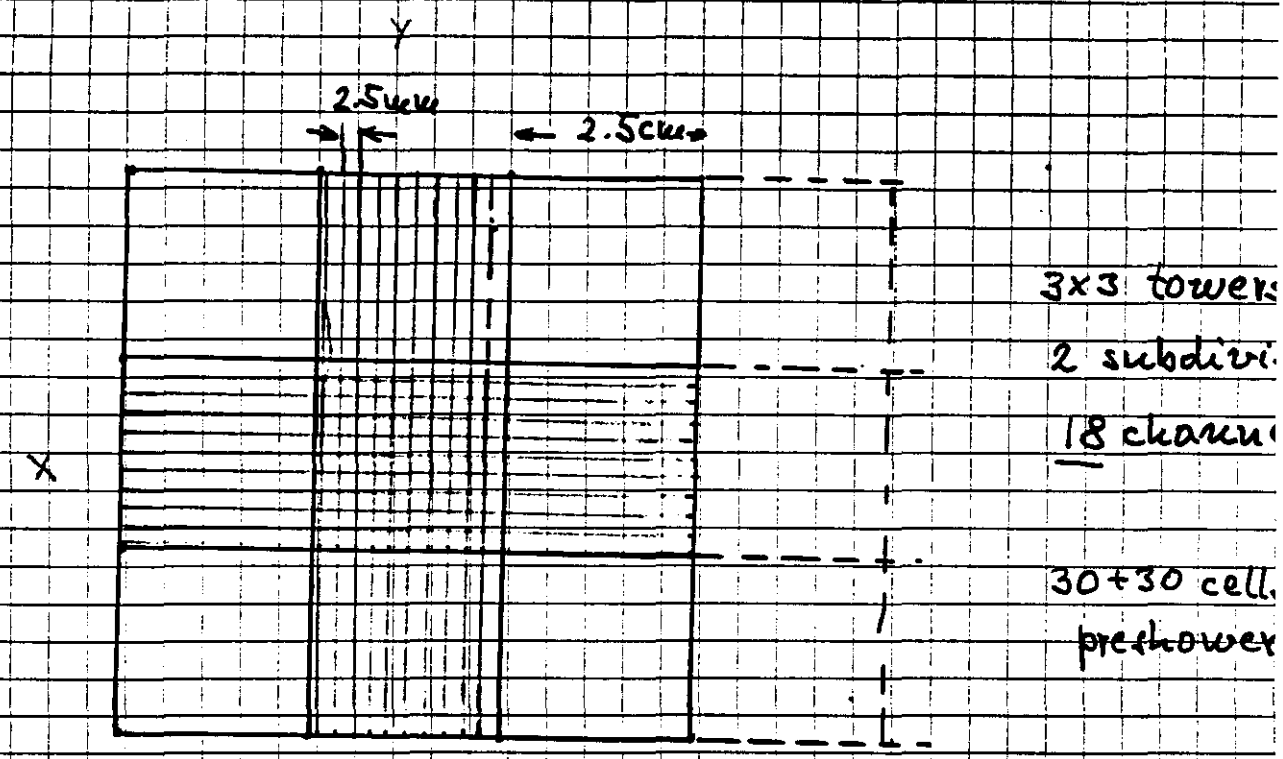


Figure 11: Inefficiency on isolated 50 Gev photons as a function of the strip length for a luminosity of $3.3.10^{34}$ $cm^{-2}s^{-1}$.

Conclusion : $\ell_s \approx 7-10$ cm

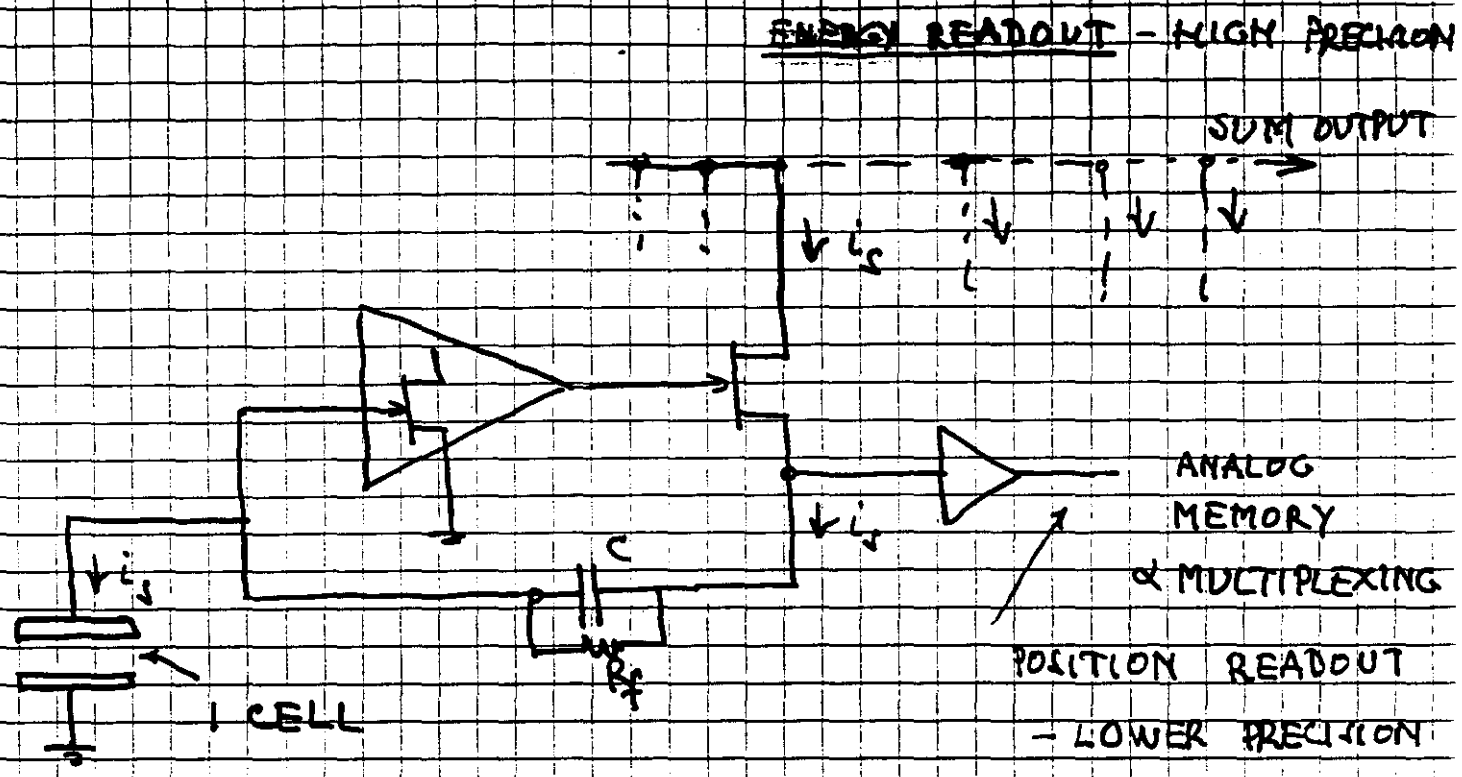


Number of channels:

Calorimeter	N
Preshower	$\gtrsim \frac{3.3}{5} N$

<u>Readout issues:</u> number of channels
calibration
noise
power dissipation
strip length (vs pileup, speed of resp
se, power dissipation

PRESHOWER READOUT



Energy readout - independent of $R_f C_f$, <u>All channels equal gain</u>
Position " - dependent on $R_f C_f$

Power dissipation has to be $\ll$ 1/4 calorimeter preamp.

<u>Big problems:</u>

Position readout → multiplexing
→ CMOS → not rad. hard at low temperatures

Optical fibers ?
Fast multiplexing → power dissipation

gem

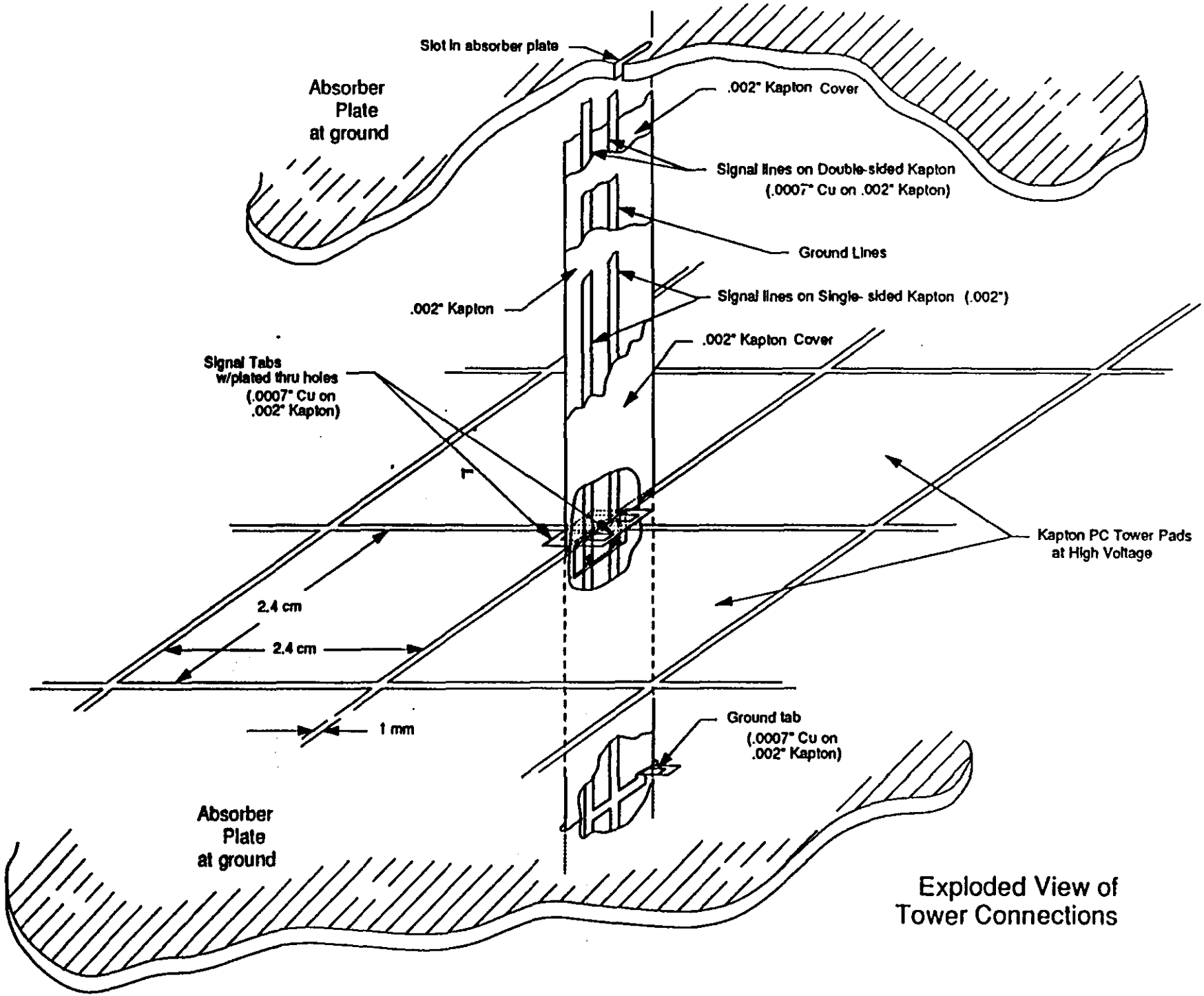
γeμ

Presentation by:

P. Mockett

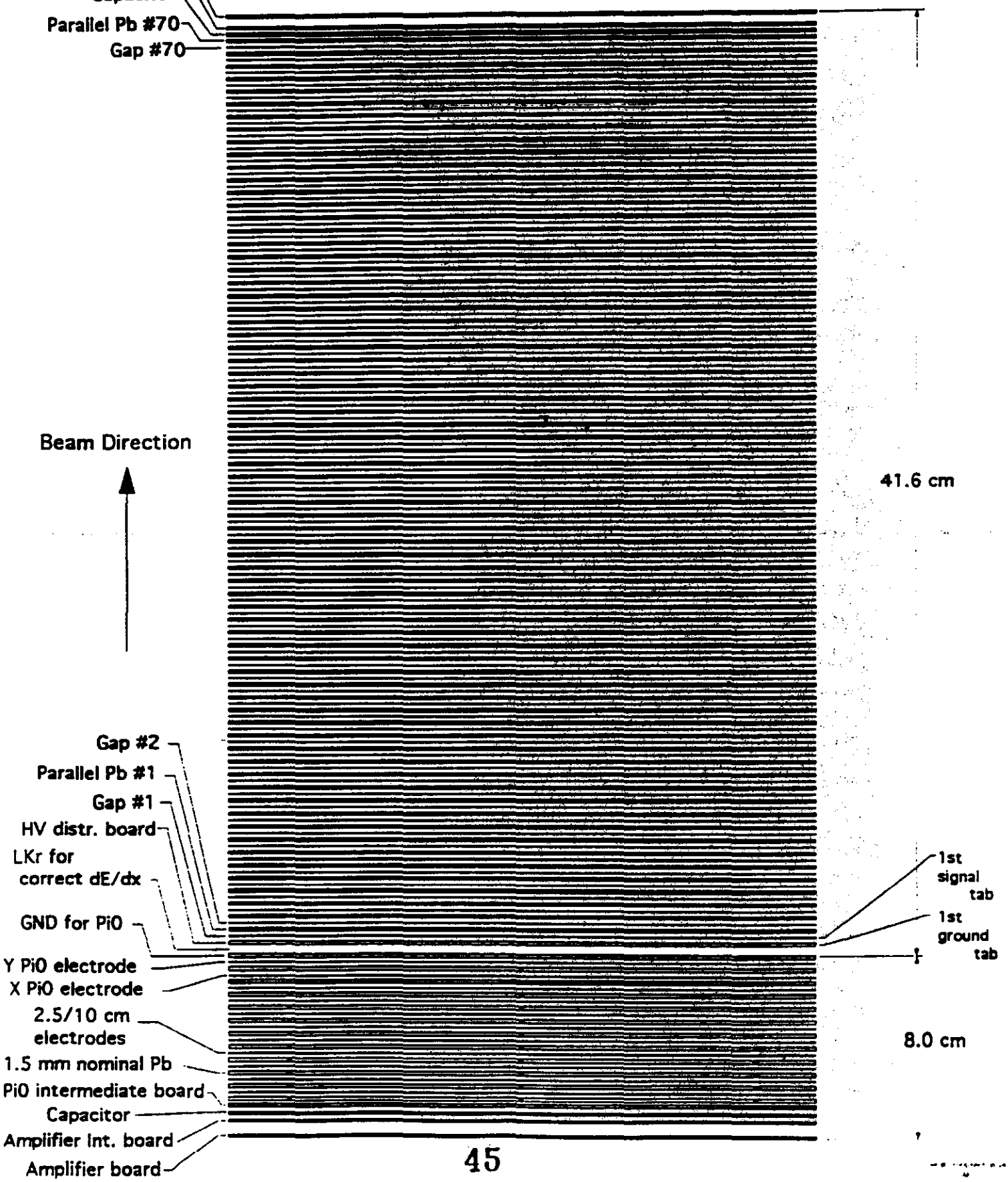
P. Mockett
Stony Brook
9/17/92

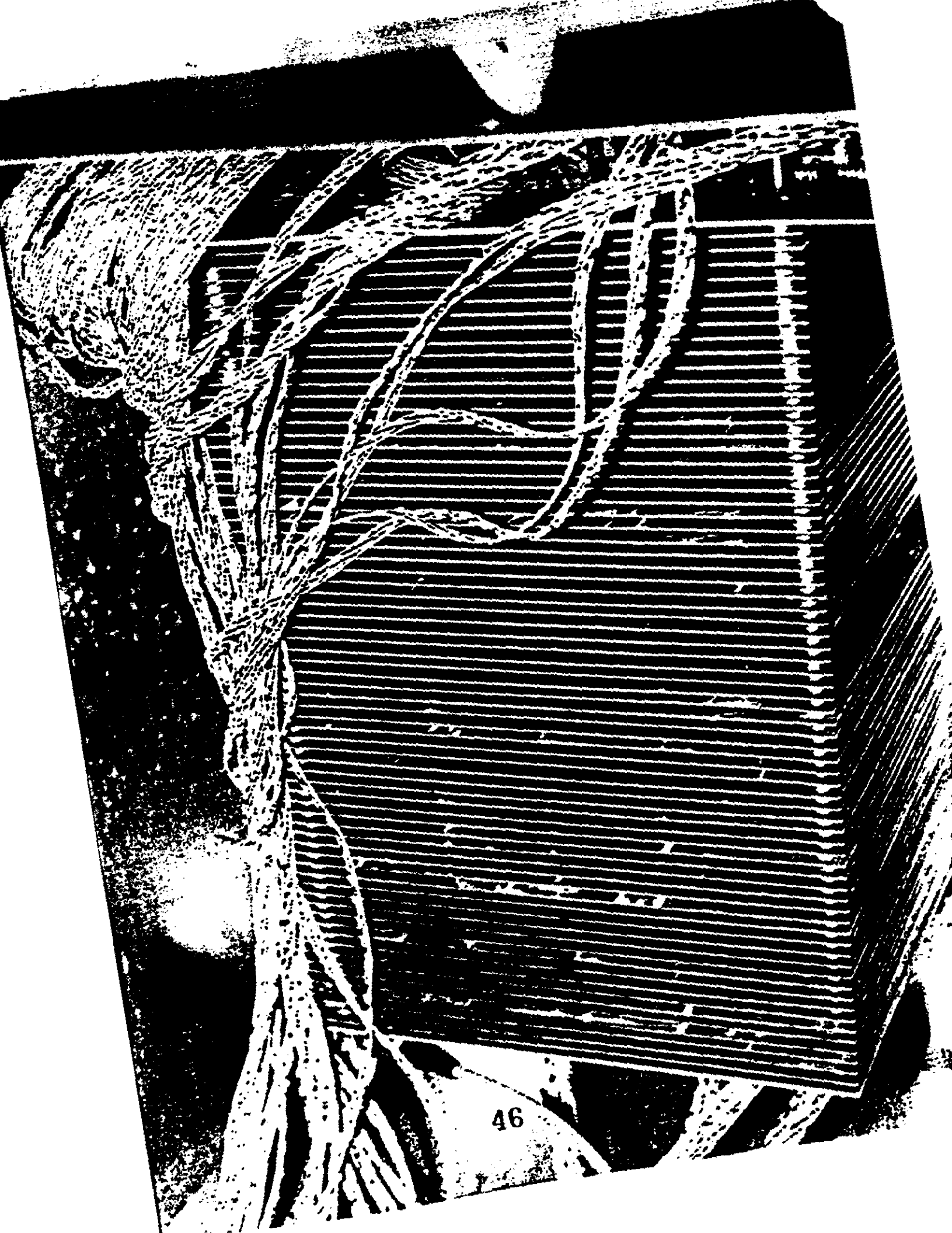
Parallel Plate -
Preradiator Solution

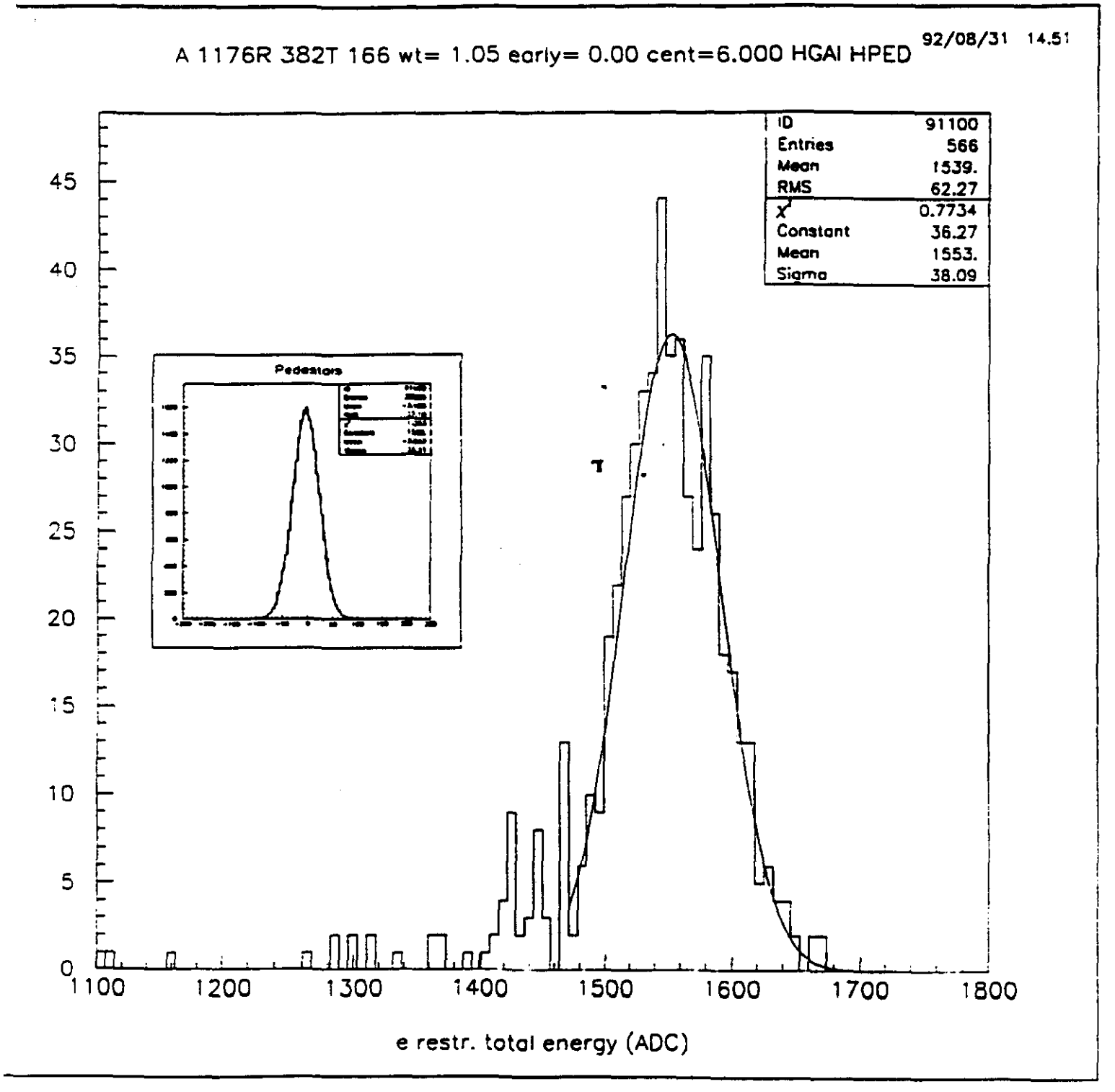


Exploded View of Tower Connections

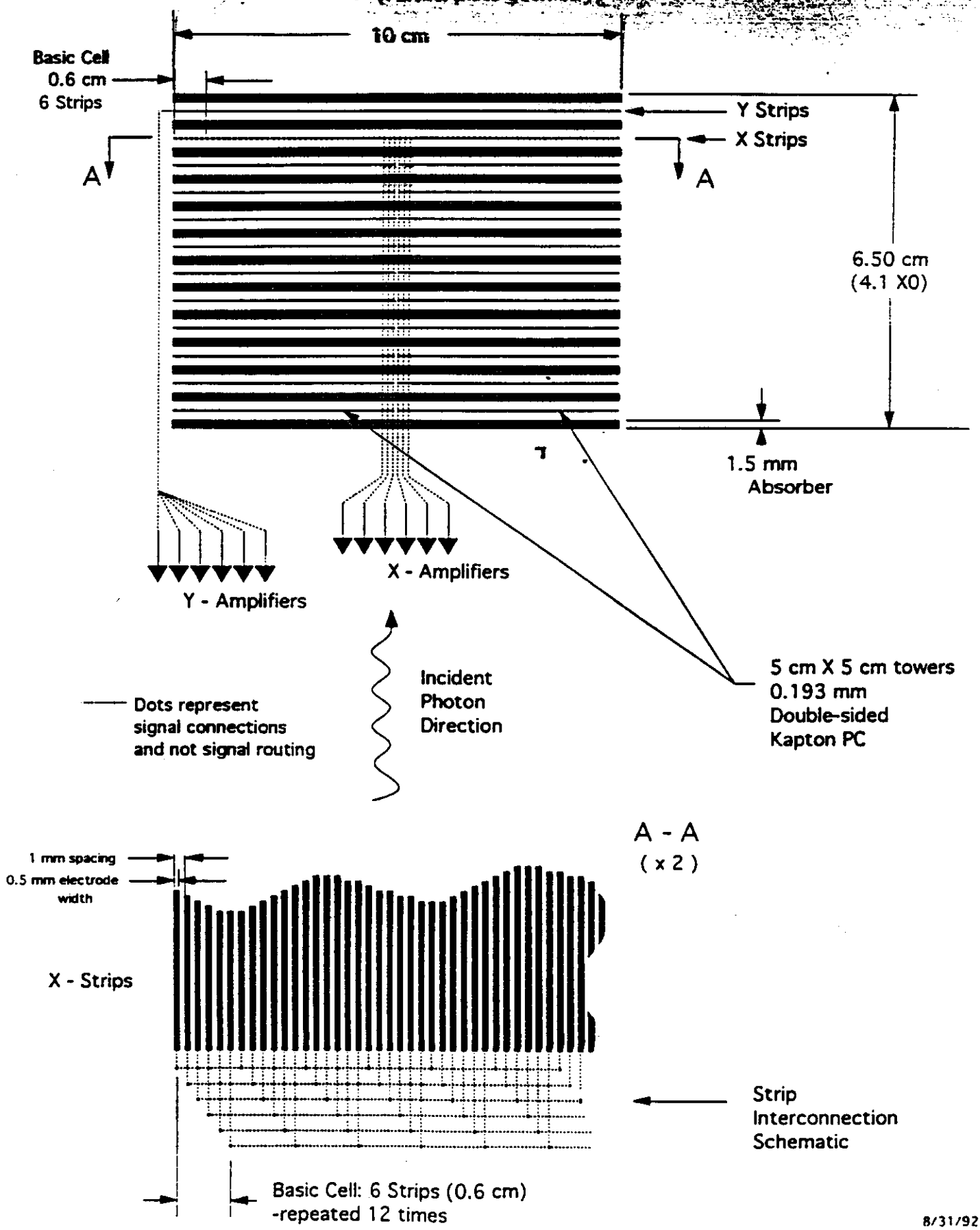
UNIVERSITY OF WASHINGTON TEST STACK



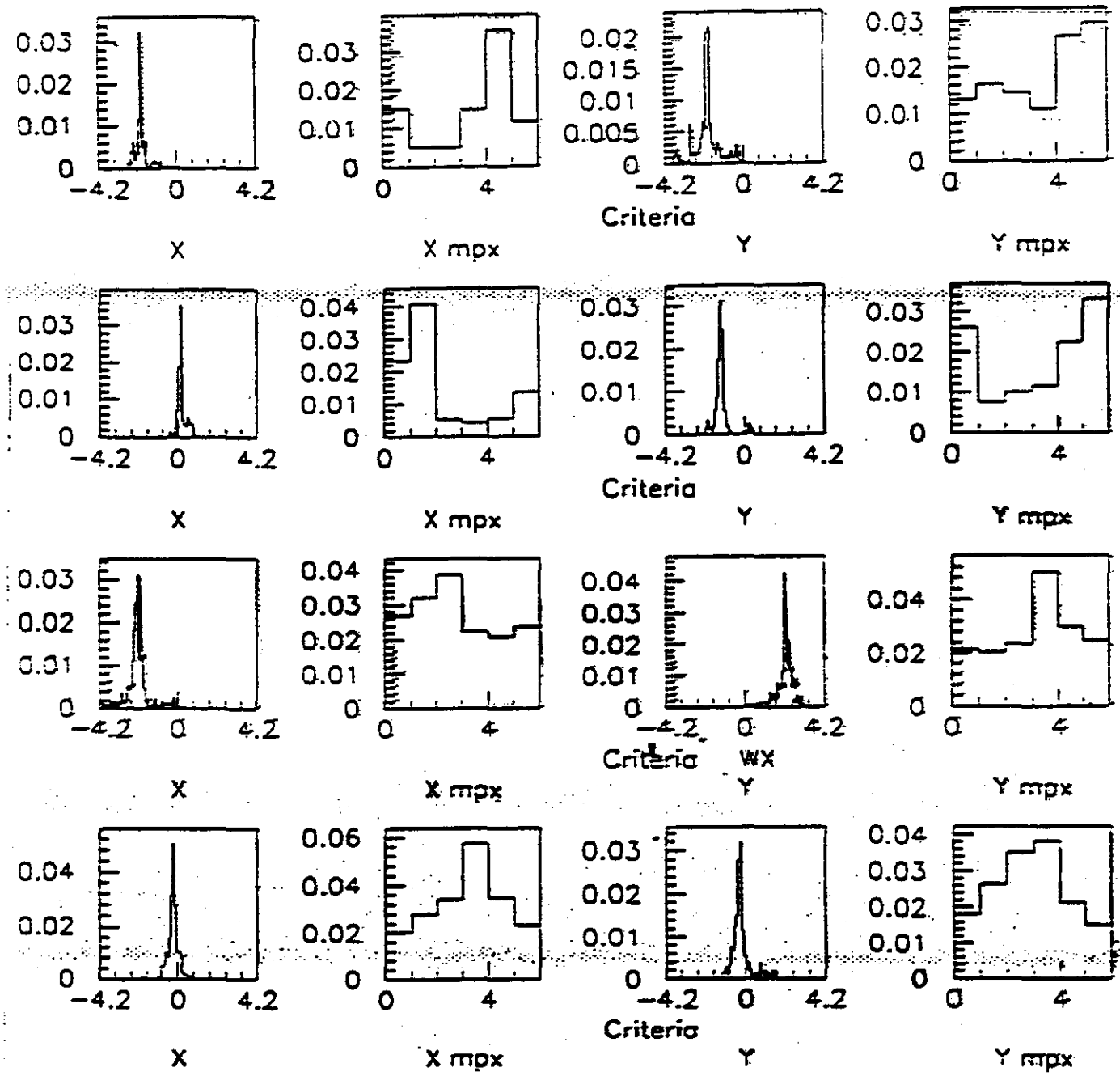




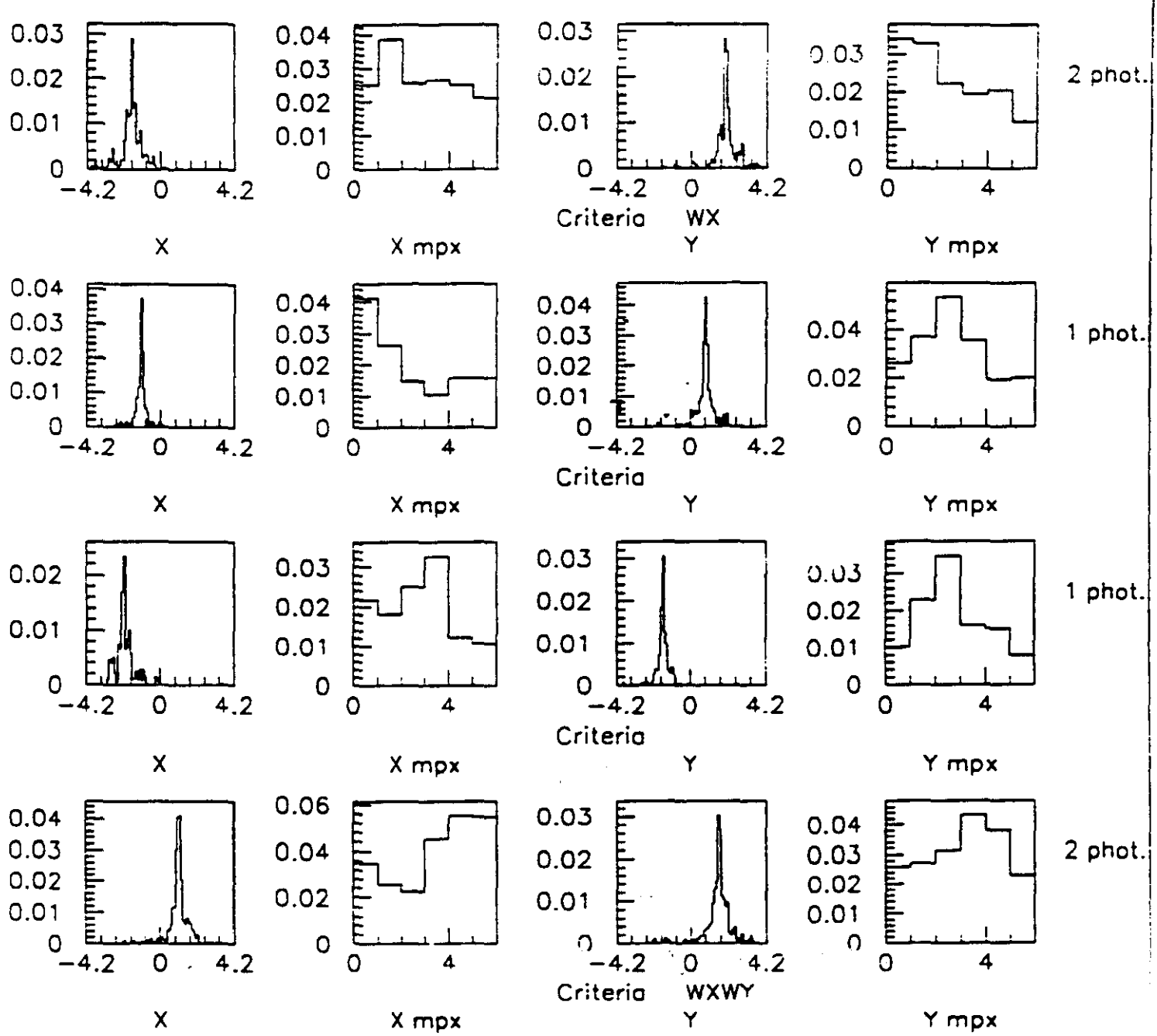
$(6.88 \pm .2)\ \frac{\%}{\sqrt{E}}$


10 cm
Basic Cell
0.6 cm
6 Strips
Y Strips
X Strips
A
A
6.50 cm
(4.1 X0)
1.5 mm
Absorber
X - Amplifiers
Y - Amplifiers
Incident
Photon
Direction
5 cm X 5 cm towers
0.193 mm
Double-sided
Kapton PC
Dots represent
signal connections
and not signal routing
A - A
(x 2)
1 mm spacing
0.5 mm electrode
width
X - Strips
Strip
Interconnection
Schematic
Basic Cell: 6 Strips (0.6 cm)
-repeated 12 times
8/31/92
DAF

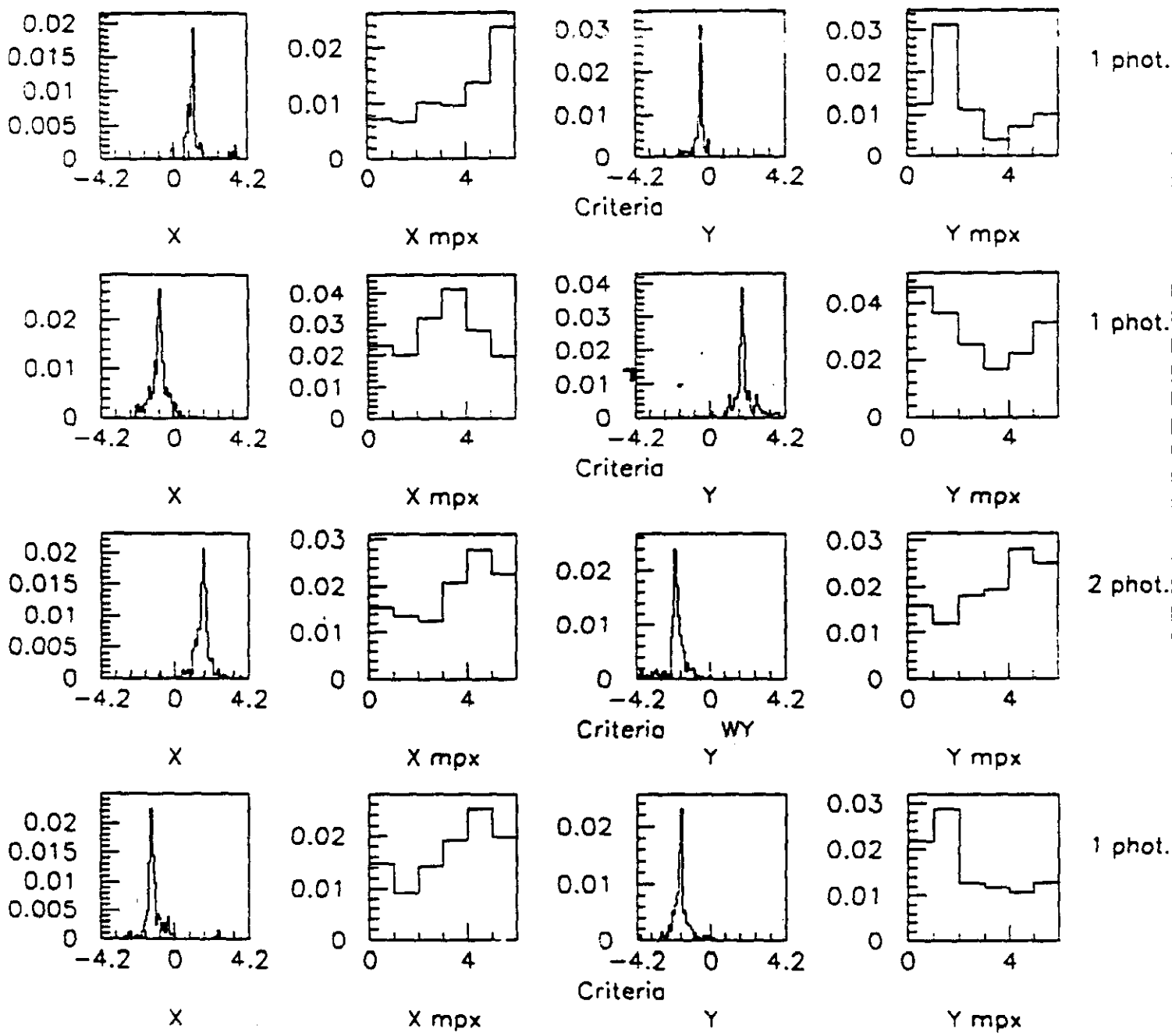
Strip width = 1.0mm multiplexing = 6 E= 15.0 part.=e− Fri Aug 21 12z17z07 1992



Strip width =1.0mm multiplexing = 6 E= 15.0 part.=e− Fri Aug 21 12z16z33 1992

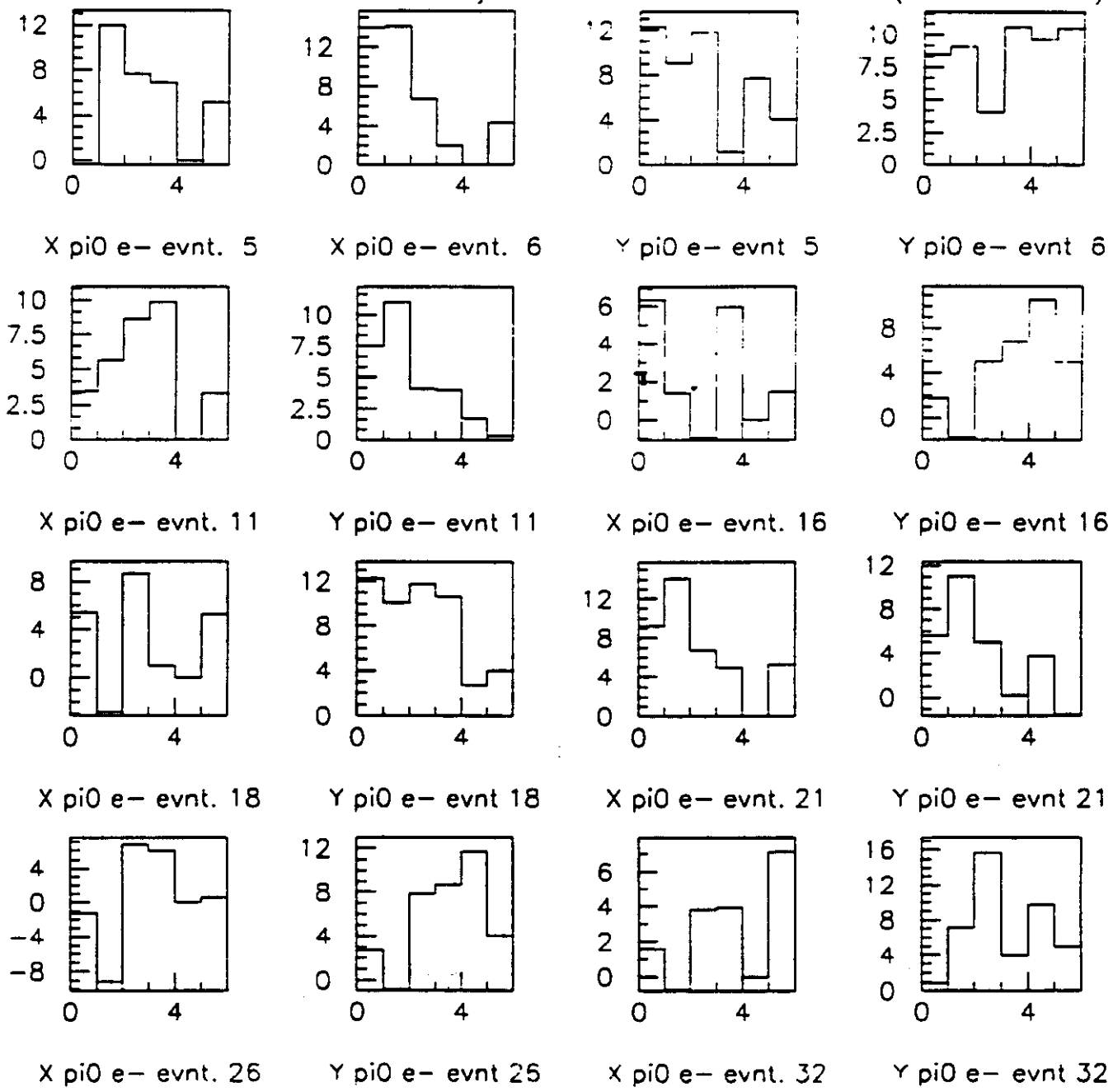


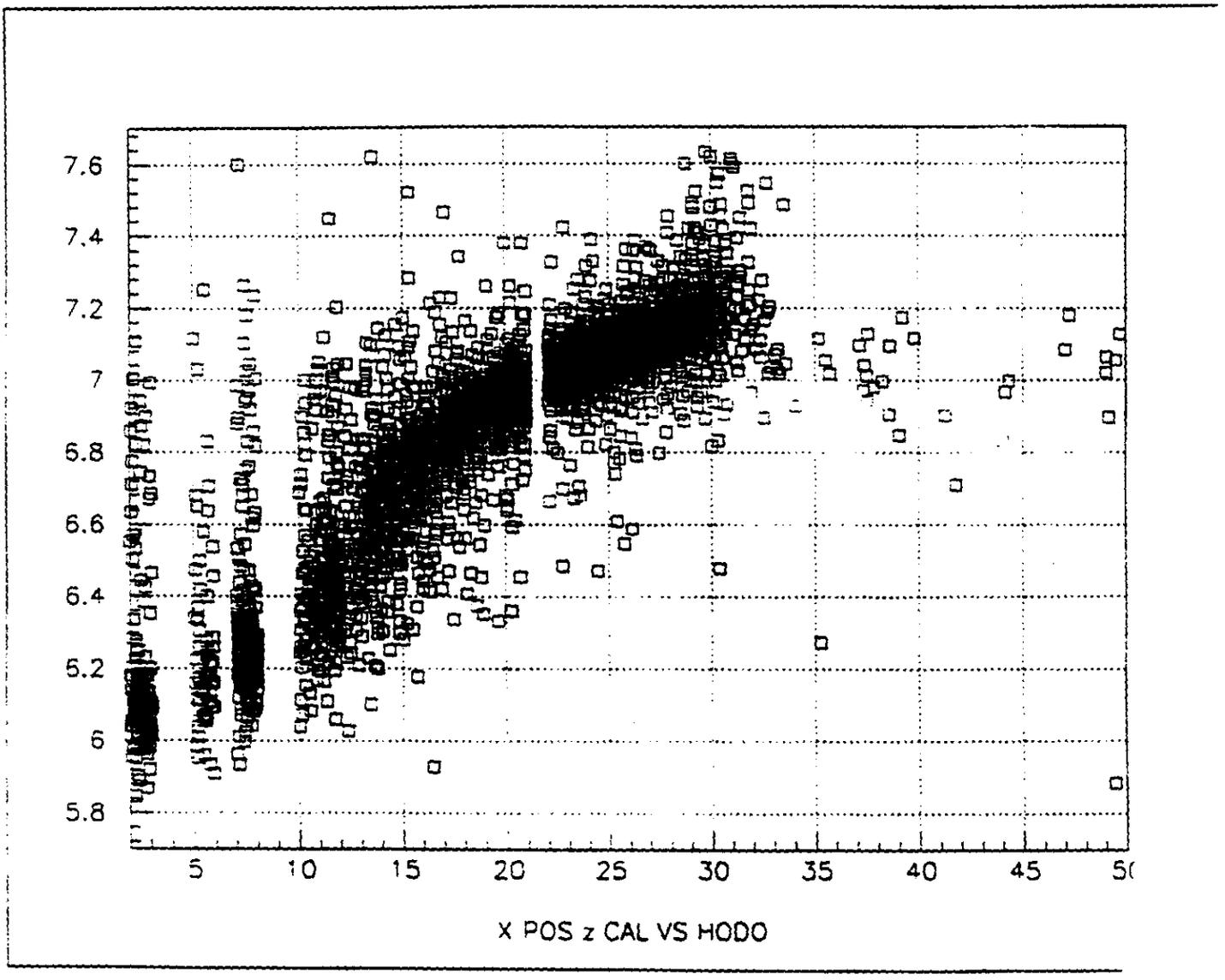
Strip width = 1.0mm multiplexing = 6 E= 15.0 part.=e− Fri Aug 21 12z16z46 1992

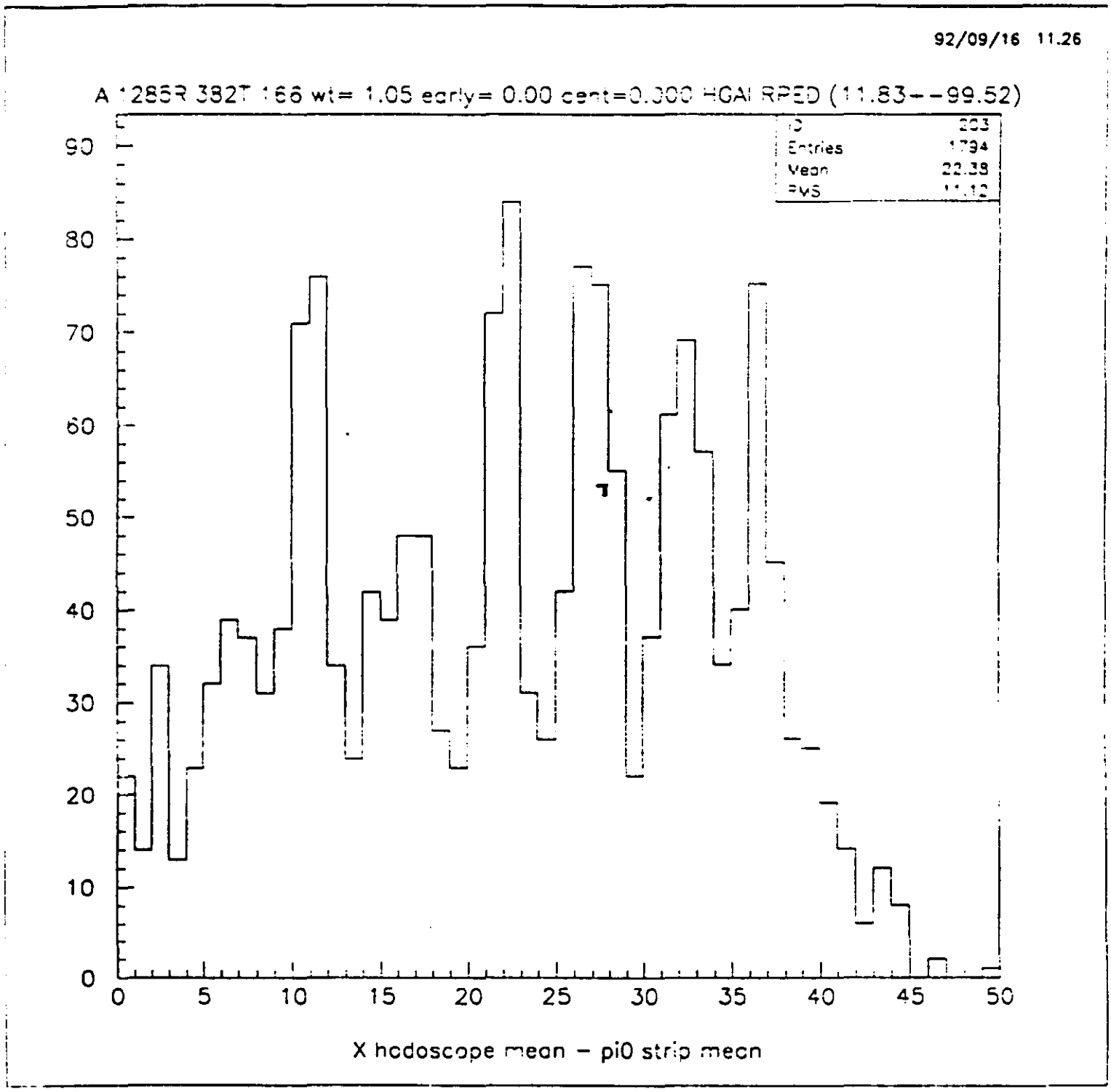


92/09/15 21.28

A 1267R 382T 166 wt= 1.05 early= 0.00 cent=0.000 HGAI RPED (11.56+-*****)




7.6
7.4
7.2
7
6.8
6.6
6.4
5.2
6
5.8
5
10
15
20
25
30
35
40
45
X POS z CAL VS HODO


92/09/16 11.26
A 1285R 382T 166 wt= 1.05 early= 0.00 cent=0.000 HGAI RPED (11.83--99.52)
ID 203
Entries 1794
Mean 22.38
RMS 11.12
90
80
70
60
50
40
30
20
10
0
0
5
10
15
20
25
30
35
40
45
50
X hodoscope mean - pi0 strip mean

[redacted]

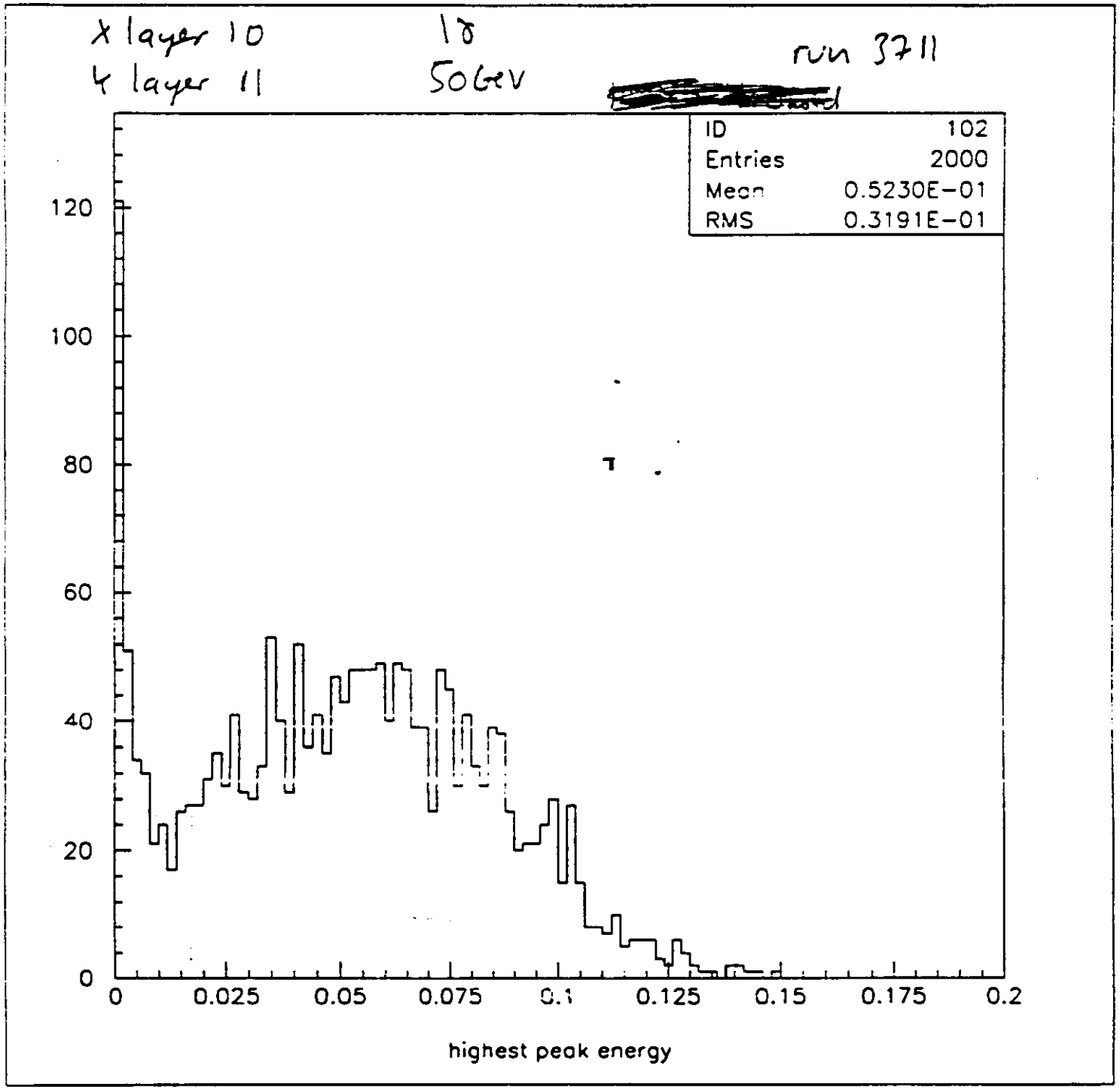
out/a1276_t166_r382.out

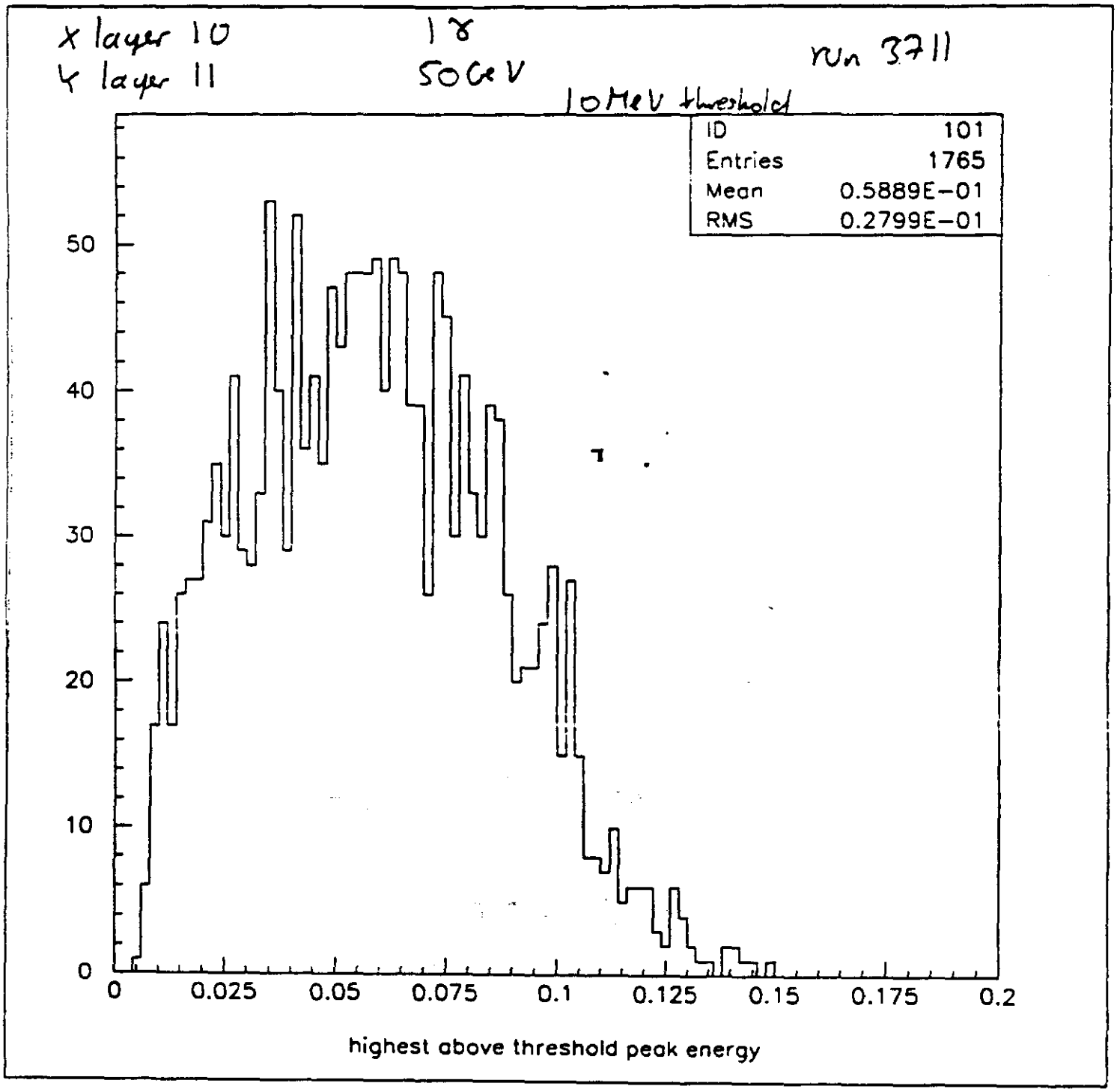
[redacted]

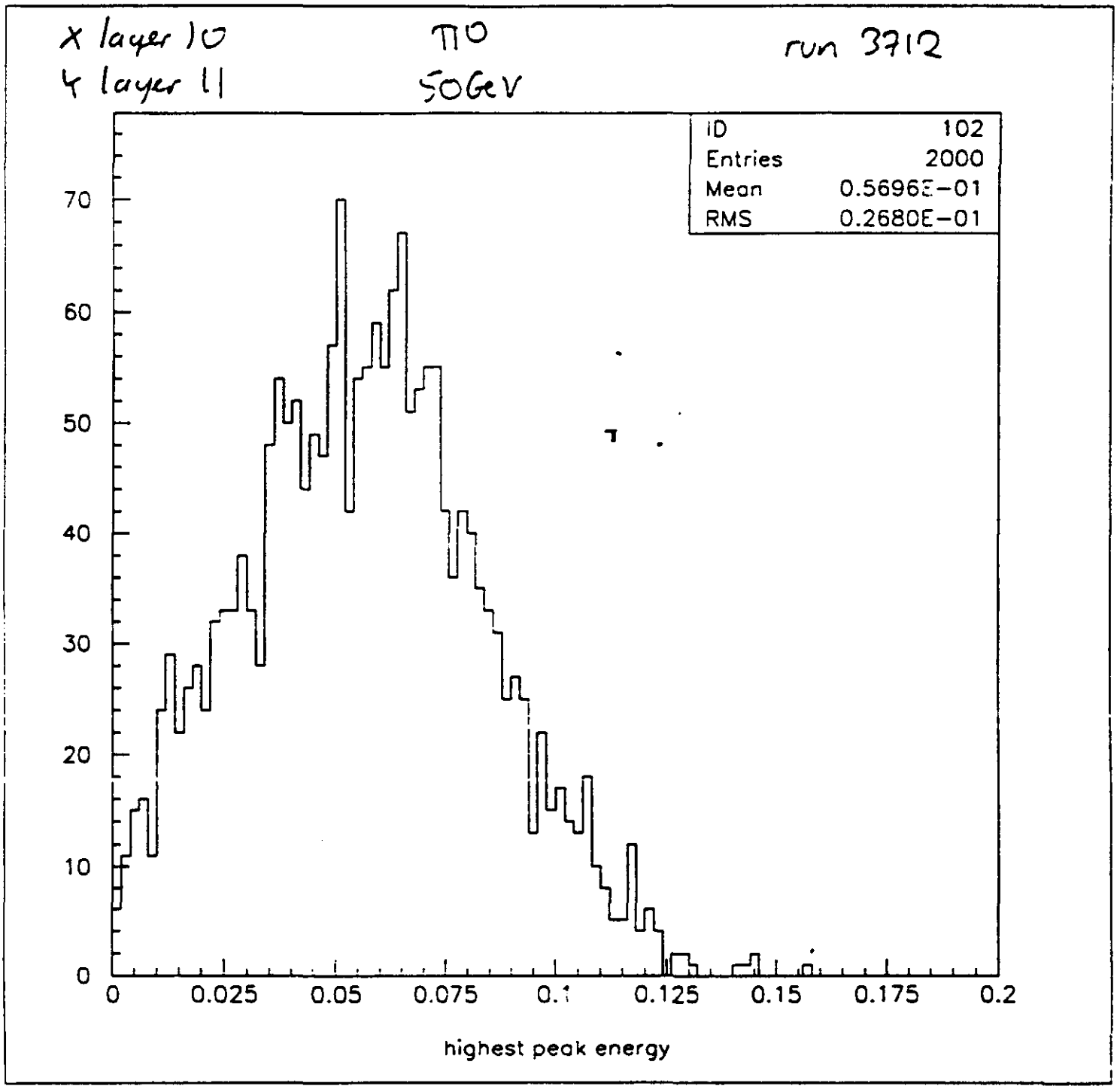
```
Reading pedestals collected from tape 166 run 382
 0.000   0.000   0.000   0.000   0.000   0.000   0.000
 0.000   0.000   0.000   0.000   0.000   0.000   0.000
 0.000   0.000   0.000   0.000   0.000   0.000   0.000
43.410  54.300  63.430  60.150  60.590  57.100  65.370
52.290  62.930  53.590  56.990  56.130  56.670  50.850
60.000  47.690  53.500  51.620  52.610  53.530  55.930
68.920  65.260  61.490  59.860  63.970  57.430  72.820
76.540  68.340  62.730  65.890  64.990  57.910  61.080
69.700  67.700  65.190  61.540  71.630  59.100  53.630
53.960  62.820  75.800  63.810  72.170  56.300  61.480
62.860  62.510  60.030  64.370  59.010  62.830  53.010
59.490  56.700  58.400  51.370  55.330  54.310  53.440
 0.000   0.000   0.000   0.000   0.000   0.000   0.000
 0.000   0.000   0.000   0.000   0.000   0.000   0.000
 0.000   0.000   0.000   0.000   0.000   0.000   0.000
 0.000   0.000   0.000   0.000   0.000   0.000   0.000
 0.000   0.000   0.000   0.000   0.000   0.000   0.000
 0.000   0.000   0.000   0.000   0.000   0.000   0.000
 0.000   0.000   0.000   0.000   0.000   0.000   0.000
79.730  60.210  74.940  61.880  68.100  62.200  67.090
68.620  61.560  66.420  66.990  56.290  62.350  60.540
58.890  62.270  62.970  60.330  69.480  68.940  71.450
61.380  59.030  61.320  64.740  64.540  62.200  63.980
58.080  47.380  56.120  54.130  47.050  68.360  55.940
56.040  52.340  64.400  57.180  66.030  59.420  66.120
72.830  49.710  55.930  43.710  56.680  60.440  64.340
59.620  66.890  56.620  59.060  54.090  65.390  54.070
61.390  52.780  65.920  60.330  56.440  50.010  67.340
 0.000   0.000   0.000   0.000   0.000   0.000   0.000
 0.000   0.000   0.000   0.000   0.000   0.000   0.000
 0.000   0.000   0.000   0.000   0.000   0.000   0.000
Run number          382
Reading tape 166 run  382
 READING GAIN FILE
 EQUALIZATION RUN          13
 CALIBRATION   RUN          19
 PEDESTAL      RUN          30
 *****   DONE *****
VGA adc constants
128 128 128 128 128 128 128 128 128 128 128 128 128 128 128 128
128 128 128 128 128 128 128 128 128 125 141 128 128 128 128 104
189 124 128 107 128 128 128 103 106 109 102 128 128 128 128 128
195 115 119 118 139 128 107 128 128 128 117 114 128 128 129 103
125 115  75 128 111 128 128 128 128 101 108 113 108 128 128  97
131 148 128 113 128 130 128 142 147 164 137 128 128 128 128 128
128 128 128 128 128 128 128 128 128 128 128 128 128 128 128 128
128 128 128 128 128 128 128 128 128 128 128 128 128 128 128 128
128 128 128 128 128 128 128 128 128 128 128 128 128 128 128 128
128 128 128 128 128 128 128 128 128 128 128 128 128 128 128 128
128 128 128 128 128 128 128 128 128 128 128 128 128 128 128 128
128 128 128 128 128 128 128 128 128 128 128 128 128 128 128 128
164 118 109 101 128 111 128 103 122 128 128 128 128 128 128  87
114 103 101 133 108 128 128 128 115 124 186 106 115 128 128 100
124 137 128 112 128 128 129 129 128 101 119 116 197 128 128 128
117 103 105 113 110 102 109 101 167  93 112 211 114  97 228 108
109 122 116 106 103 128 128 128 128 128 128 128 128 128 128 128
128 128 128 128 128 128 128 128 128 128 128 128 128 128 128 128
fera adc gains      1.000
   0.002   0.014   1.175   1.150   0.520   0.002   0.001   1.033
   0.903   1.108   0.006   1.147   0.000   0.009   0.004   1.159
   1.142   1.113   1.147   0.001   0.000   0.000   0.000   0.000
   0.826   1.148   1.116   1.176   1.189   0.000   1.102   0.002
   0.866   0.901   1.124   1.194   0.001   0.002   1.138   1.174
   1.158   1.044   1.141   0.000   1.142   0.000   0.000   0.000
```

π0 pedrms

```
   0.000   1.161   1.115   1.108   1.130   0.000   0.000   1.151
   1.133   1.128   0.000   1.105   0.000   1.124   0.000   1.14[illegible]
   1.100   1.140   1.165   0.000   0.000   0.000   0.000   0.00[illegible]
   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
   1.208   1.154   1.163   1.184   0.943   1.157   0.002   1.164
   1.154   1.186   0.000   0.000   0.000   0.000   0.000   1.162
   1.173   1.152   1.160   0.995   1.130   0.000   0.000   0.000
   1.193   1.096   1.167   1.236   1.151   0.000   0.000   1.211
   1.241   1.196   0.000   1.156   0.000   0.000   1.155   1.192
   1.147   1.167   1.166   1.057   0.976   0.000   0.000   0.00[illegible]
   1.195   1.177   1.104   1.066   1.122   1.141   1.176   1.15[illegible]
   0.014   1.192   1.119   1.140   1.149   1.098   1.039   1.14[illegible]
   1.160   1.189   1.137   1.150   1.163   0.000   0.000   [illegible]
   0.000   0.000   0.000   0.000   0.000   0.000   0.000   [illegible]
fera adc ped
  59.528  56.450  57.994  51.590  55.318  54.038  [illegible]
  63.510  59.678  64.632  59.950  62.676  52.994  54.1[illegible]  [illegible]
  76.282  64.296  72.418  56.140  61.510  61.325  69.540  54.98[illegible]
  71.224  67.770  65.016  60.830  71.856  59.330  54.014  [illegible]
  68.626  63.210  66.374  65.462  58.168  61.698  64.729  65.615
  61.800  59.120  63.372  57.024  73.102  67.102  57.926  [illegible]
  60.000  47.286  53.402  51.436  52.922  53.270  55.774  52.0[illegible]
  63.050  53.900  57.476  56.492  56.948  50.707  44.012  54.373
  63.516  60.704  60.836  56.914  66.034  62.980  54.566  [illegible]
  74.000  74.000  76.000  77.000  75.000  73.000  75.000  71.00[illegible]
  73.434  60.142  74.318  61.092  68.452  62.592  67.046  [illegible]
  62.056  67.658  67.808  56.842  63.030  60.594  59.910  [illegible]
  63.099  59.972  69.036  68.380  70.616  63.618  64.832  64.1[illegible]
  61.394  58.758  60.462  64.760  64.788  [illegible]2.128  64.165  [illegible]
  44.888  56.114  [illegible]4.136  45.764  68.234  [illegible]56  53.980  [illegible]
  64.036  58.044  55.096  58.980  65.068  [illegible]314  51.50[illegible]  [illegible]
  72.198  49.954  [illegible]4.882  44.026  57.254  [illegible]139  64.295  [illegible]
  66.142  57.402  [illegible]8.776  54.790  65.644  [illegible]580  60.669  [illegible]
  66.052  60.450  [illegible]5.594  49.186  67.256  [illegible]257  64.972  [illegible]
  73.000  74.000  [illegible]7.000  68.000  76.000  [illegible]00  69.000  [illegible]
fera adc pedrms
   2.211   2.097   2.752   2.722   2.297   [illegible]43   2.0[illegible]   [illegible]
   6.081   2.219   1.998   2.595   1.977   [illegible]37   1.914   [illegible]
   2.415   2.432   2.640   2.168   1.994   [illegible]176   2.063   [illegible]
   9.766   [illegible]   2.562   3.584   2.908   [illegible]120   3.955   [illegible]241
   2.142   2.11[illegible]   [illegible]016   2.505   1.898   [illegible]172   3.6[illegible]   [illegible]
   2.637   5.66[illegible]   2.248   2.036   3.704   [illegible]601   2.0[illegible]   [illegible]
   0.000   2.686   [illegible]520   2.535   2.141   [illegible]089   2.0[illegible]   [illegible]
   3.648   2.440   2.086   2.380   2.021   [illegible]714   2.012   [illegible]
   2.881   2.911   2.692   2.162   1.980   [illegible]766   1.916   [illegible]
   0.000   0.000   0.000   0.000   0.000   [illegible]000   0.000   [illegible]
   5.142   4.90[illegible]   4.603   4.702   4.318   [illegible]882   2.063   [illegible]
   4.547   5.009   4.953   4.864   4.815   [illegible]820   1.888   [illegible]
   4.360   4.527   [illegible].986   3.553   4.764   [illegible]830   1.668   [illegible]
   4.665   4.44[illegible]   4.585   5.032   4.430   [illegible]899   1.881   [illegible]
   6.020   4.461   [illegible].939   4.758   1.750   [illegible]896   4.231   [illegible]
   4.654   4.279   4.731   2.044   6.571   [illegible]235   1.713   [illegible]
   5.740   4.989   [illegible].923   4.064   4.096   [illegible]162   5.103   [illegible]
   2.218   4.738   [illegible].223   5.131   4.710   [illegible]180   4.061   [illegible]
   4.233   5.145   [illegible].753   5.189   3.670   [illegible]155   1.953   [illegible]
   0.000   0.000   [illegible].000   0.000   0.000   [illegible]000   0.00[illegible]   [illegible]
beam and veto counter [illegible]
  16.514  15.966  10.64[illegible]  14.060  66.194   2.000  14.09[illegible]  11.000  14.[illegible]  [illegible]
12.920
  30.640  29.240  28.702  27.786  29.281  29.850  19.000  18.000  31.234  [illegible]  [illegible]
27.158
  41.226  39.572  12.000  11.000  11.000  13.000  13.000  12.000  13.000  [illegible]  [illegible]
11.000
beam and veto counter pedrms
```


x layer 10
4 layer 11
1γ
50GeV
run 3711
ID 102
Entries 2000
Mean 0.5230E-01
RMS 0.3191E-01
120
100
80
60
40
20
0
0
0.025
0.05
0.075
0.1
0.125
0.15
0.175
0.2
highest peak energy


x layer 10
y layer 11
1 γ
50 GeV
run 3711
10 MeV threshold
ID 101
Entries 1765
Mean 0.5889E-01
RMS 0.2799E-01
0
10
20
30
40
50
0
0.025
0.05
0.075
0.1
0.125
0.15
0.175
0.2
highest above threshold peak energy


x layer 10
y layer 11
π0
50GeV
run 3712
ID 102
Entries 2000
Mean 0.5696E-01
RMS 0.2680E-01
70
60
50
40
30
20
10
0
0
0.025
0.05
0.075
0.1
0.125
0.15
0.175
0.2
highest peak energy

2

x layer 8
y layer 9

```
=================================================================
:    : 3101
=================================================================

ltiplexing:
-----------
ltiplexing factor                          [NMPX]= 6

ak definition:
--------------
ergy required for peak (GeV)               [ECUT]= .015
n. frac. of biggest peak for second     [PEAKCUT]= 0.25

p cut:
------
nst for max frac. of biggest peak      [DICONST]= 1.11
nst for max frac. of biggest peak        [DIPMAX]= -.013
ergy power for max frac. of biggest peak[DIPPOWR]= 1.
ergy to set fraction to HEDIP             [EDIP]=50.
p fraction above EDIP                     [HEDIP]= 0.5
ergy above which dip cut is on            [EDLOW]= 51.

p fraction    = DIPCONST + DIPMAX * E^DIPPOWR : EDLOW<=E<EDIP
                      = HEDIP                          : E>= EDIP
                      = cut turned off                 : E<EDLOW

dth cut:
--------
ltiplier for width cut below WCTHRESH    [CUTWID]= 6.96
wer of energy for width cut             [WIDPOWR]= -.25
ergy thresh where widthcut->NWCLOWER   [WCTHRESH]= 50.
gher energy width cut                  [NWCLOWER]= 2
n. frac. of biggest peak for width      [EWIDCUT]= 0.6

dth bin height cut    = INT(CUTWID * E^WIDPOWR)        : E < WCTHESH
                            = NWCLOWER                       : E>= EDIP

an position cut:
----------------
an offset for pi0 (in mm)               [CUTMEAN]= 6.75          bins, not cm!
wer of energy for mean offset scaling   [CUTPOWR]= -0.5
t. energy above which CUTMEAN->HEMEAN    [CUTOFF]= 51.
an difference cut above CUTOFF           [HEMEAN]= 0.65

an offset cut = CUTMEAN*E^CUTPOWR      : E<CUTOFF
                      = HEMEAN                 : E>= HEMEAN
```

92/03/17
19:36:56

1

==========
Runs in: /usr/users/jke/gem/pi0/geant/bp/v3/1mm_last1_shallow
Cut : 3101
==========

x layer 8
y layer 9

E,GeV		accep	%0	%1	%2	%mean	only	%dip	only	%wid	only	run
5.0	1	97.8	35.8	62.0	2.2	0.0	0.0	0.0	0.0	2.2	2.2	3727
5.0	7	10.4	37.2	52.4	10.4	7.6	7.2	0.0	0.0	3.2	2.8	3729
10.0	1	97.6	32.4	65.2	2.4	0.0	0.0	0.0	0.0	2.4	2.4	3730
10.0	7	46.4	15.2	38.4	46.4	41.0	33.4	0.0	0.0	13.0	5.4	3731
17.0	1	99.0	26.0	73.0	1.0	0.0	0.0	0.0	0.0	1.0	1.0	3732
17.0	7	62.0	12.4	25.6	62.0	58.6	51.4	0.0	0.0	10.6	3.4	3733
25.0	1	99.2	25.4	73.8	0.8	0.6	0.6	0.0	0.0	0.2	0.2	3734
25.0	7	68.2	8.8	23.0	68.2	64.8	57.8	0.0	0.0	10.4	3.4	3735
37.0	1	97.2	23.6	73.6	2.8	1.0	0.8	0.0	0.0	2.0	1.8	3737
37.0	7	75.0	7.2	17.8	75.0	71.8	57.4	0.0	0.0	17.6	3.2	3738
50.0	1	98.0	19.4	78.6	2.0	0.8	0.8	0.0	0.0	1.2	1.2	3739
50.0	7	67.0	6.6	26.4	67.0	64.4	50.0	0.0	0.0	17.0	2.6	3740
62.0	1	95.2	18.2	77.0	4.8	2.8	1.0	2.8	1.0	1.0	1.0	3742
62.0	7	78.0	5.2	16.8	78.0	68.4	35.4	35.2	5.8	14.6	1.0	3743
75.0	1	96.6	17.0	79.6	3.4	3.0	0.8	2.6	0.4	0.0	0.0	3744
75.0	7	80.2	3.0	16.8	80.2	69.6	32.0	41.6	6.4	15.2	2.0	3745
87.0	1	97.4	22.6	74.8	2.6	1.4	0.2	1.8	0.8	0.6	0.4	3747
87.0	7	74.8	6.4	18.8	74.8	61.8	25.6	43.2	10.6	12.4	1.4	3748
100.0	1	97.4	18.8	78.6	2.6	1.6	0.4	2.0	0.8	0.2	0.2	3749
100.0	7	69.6	6.0	24.4	69.6	54.4	26.2	37.6	12.2	10.0	2.4	3750
112.0	1	97.4	15.2	82.2	2.6	1.0	0.2	2.2	1.4	0.2	0.2	3751
112.0	7	67.0	7.2	25.8	67.0	50.6	21.6	37.6	10.0	12.8	5.4	3752
125.0	1	98.8	19.2	79.6	1.2	0.4	0.0	1.0	0.6	0.2	0.2	3753
125.0	7	62.8	4.2	33.0	62.8	46.2	19.2	31.8	7.6	16.6	8.6	3754
150.0	1	98.4	17.0	81.4	1.6	1.0	0.4	1.2	0.6	0.0	0.0	3755
150.0	7	49.4	4.2	46.4	49.4	32.8	16.8	19.4	6.4	15.4	11.2	3756

92/03/10
12:21:34

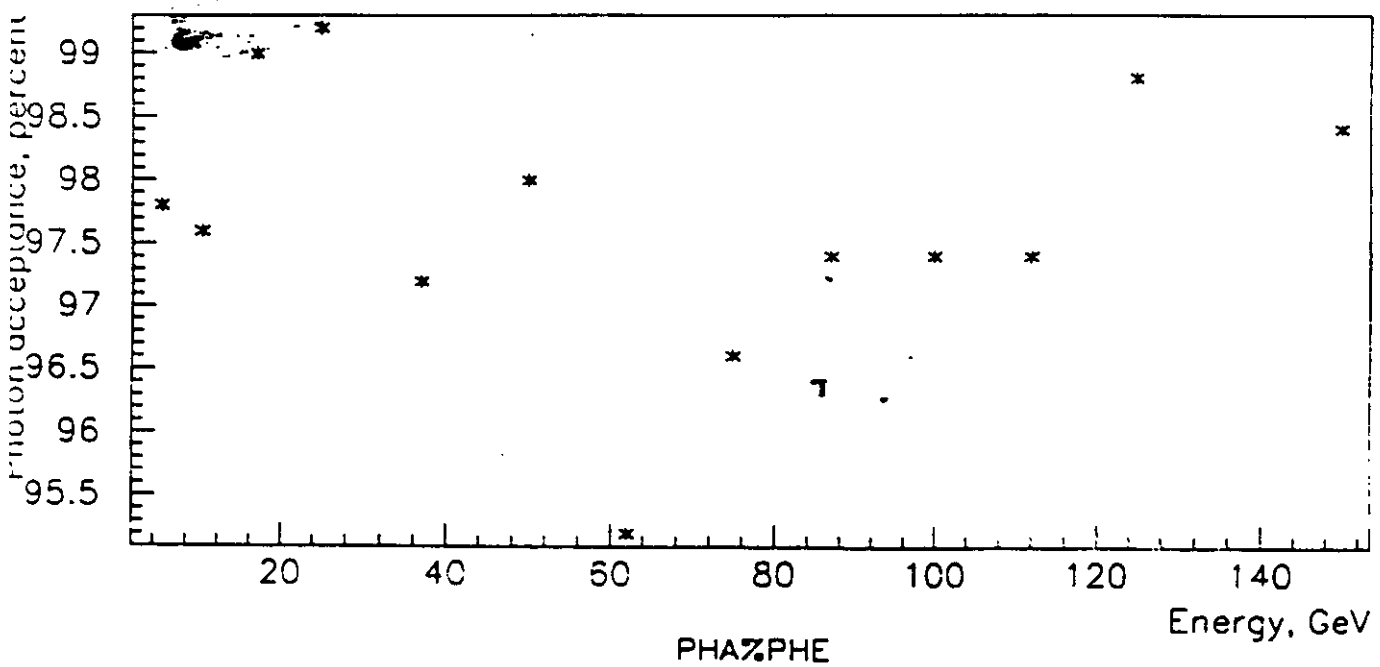
WIDSTR .1

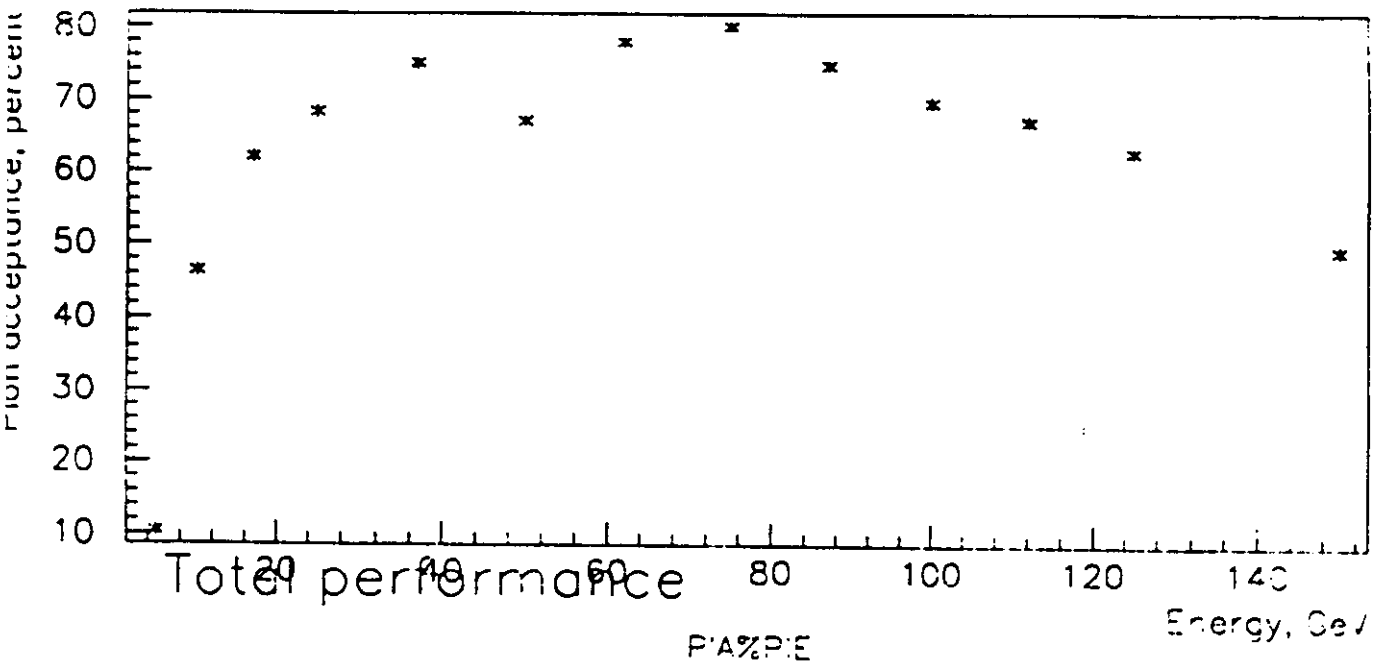
NLAYERS 9
NACTIVE 1

THPB .15
WIDPB 6.4

x layer 8
y layer 9

Cut 3101 in /usr/users/jke/gem/pi0/geant/bp/v3/1mmzlast1zshallow





Total performance

for layers 8 & 9, ~~[illegible]~~
low threshold for peaks to 10 MeV

→ cut 3102

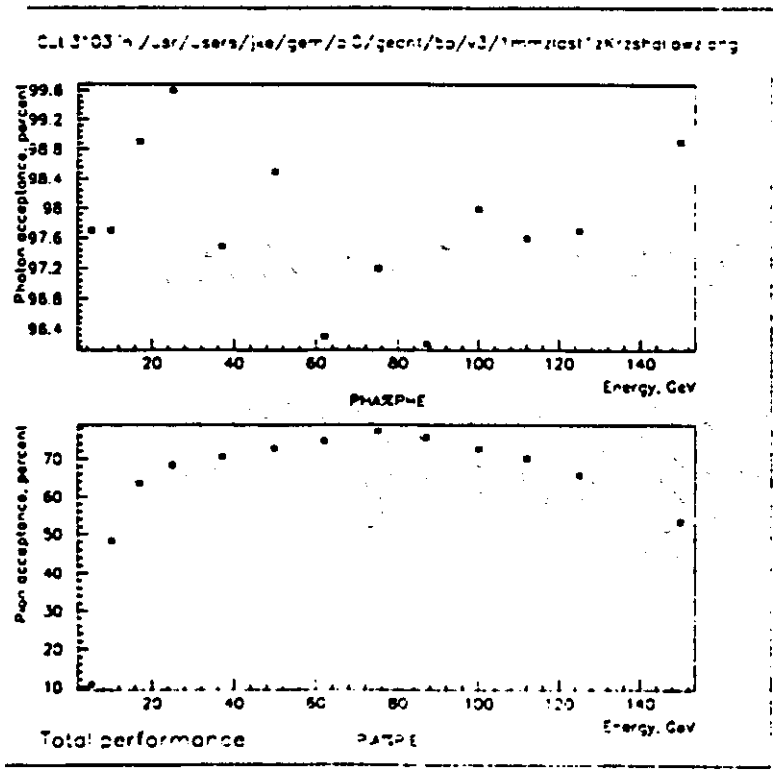
raise cutoff 51 → 63 GeV

24/92 histogram largest peak energy if above threshold in histogram 101 from Select

run this for cut 3102 10 MeV cutoffs

raise threshold to 15 MeV → cut 3103

1/92



gem

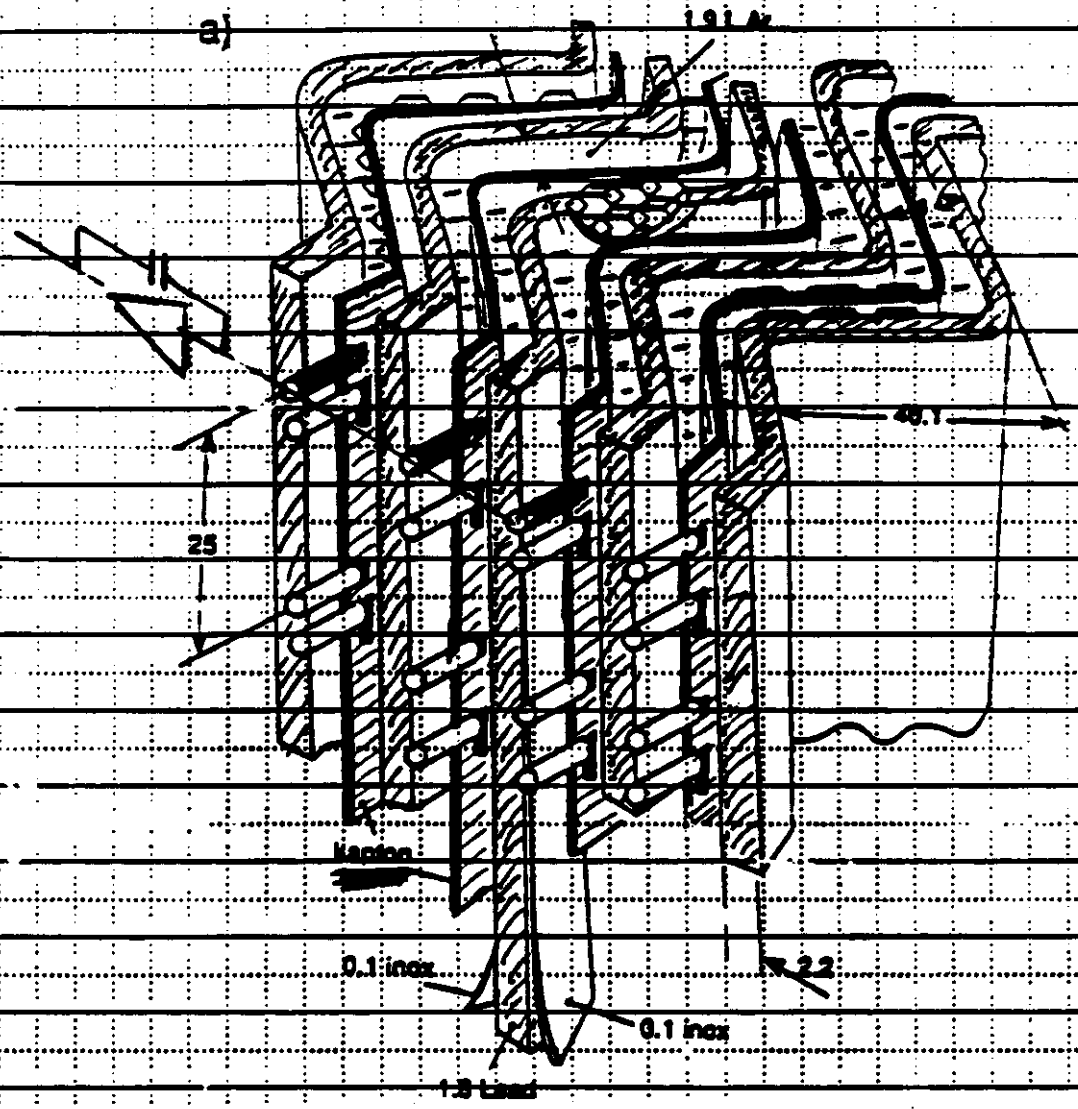
γeμ

Presentation by:

M. Leltchouk

RD3

a)



θ

φ

Options

1) θ strips

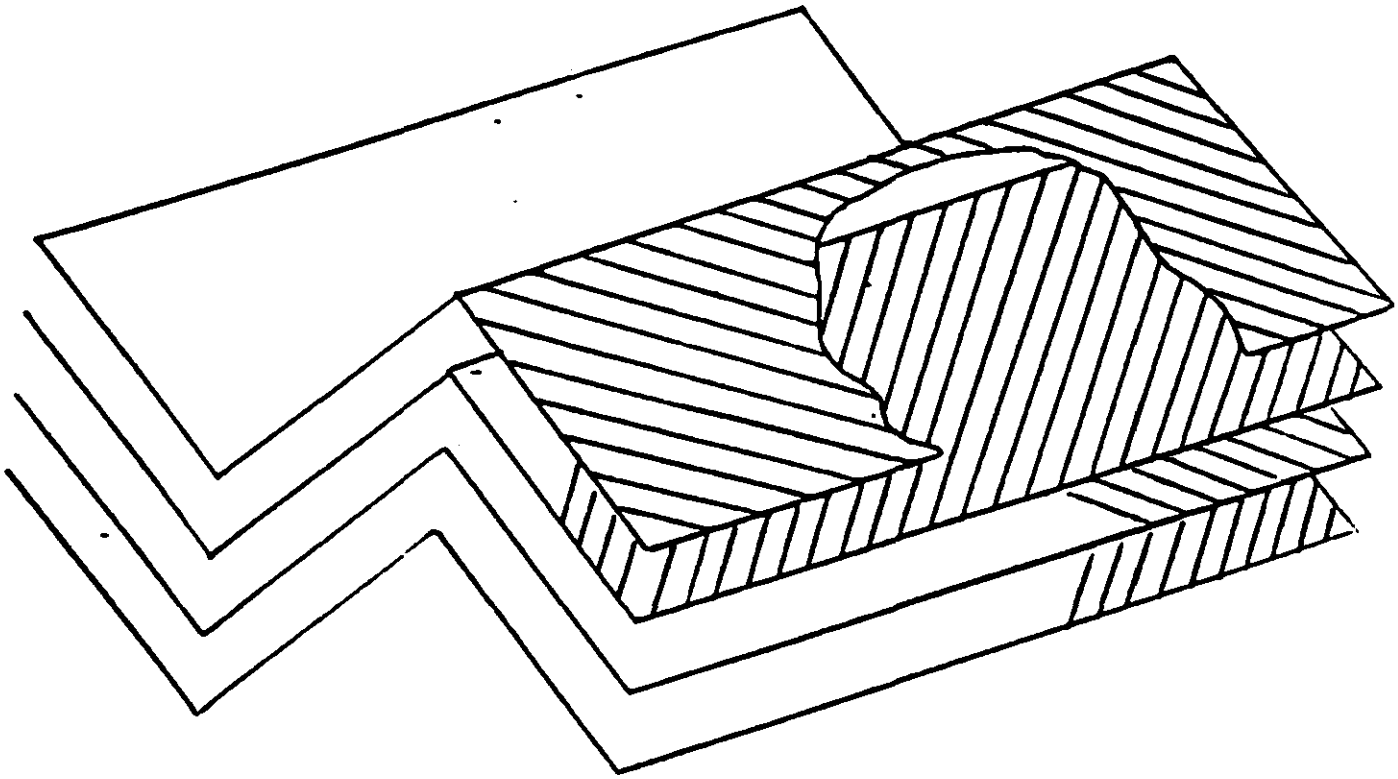
1a) θ strips
after short 1st floor

2) U, V strips

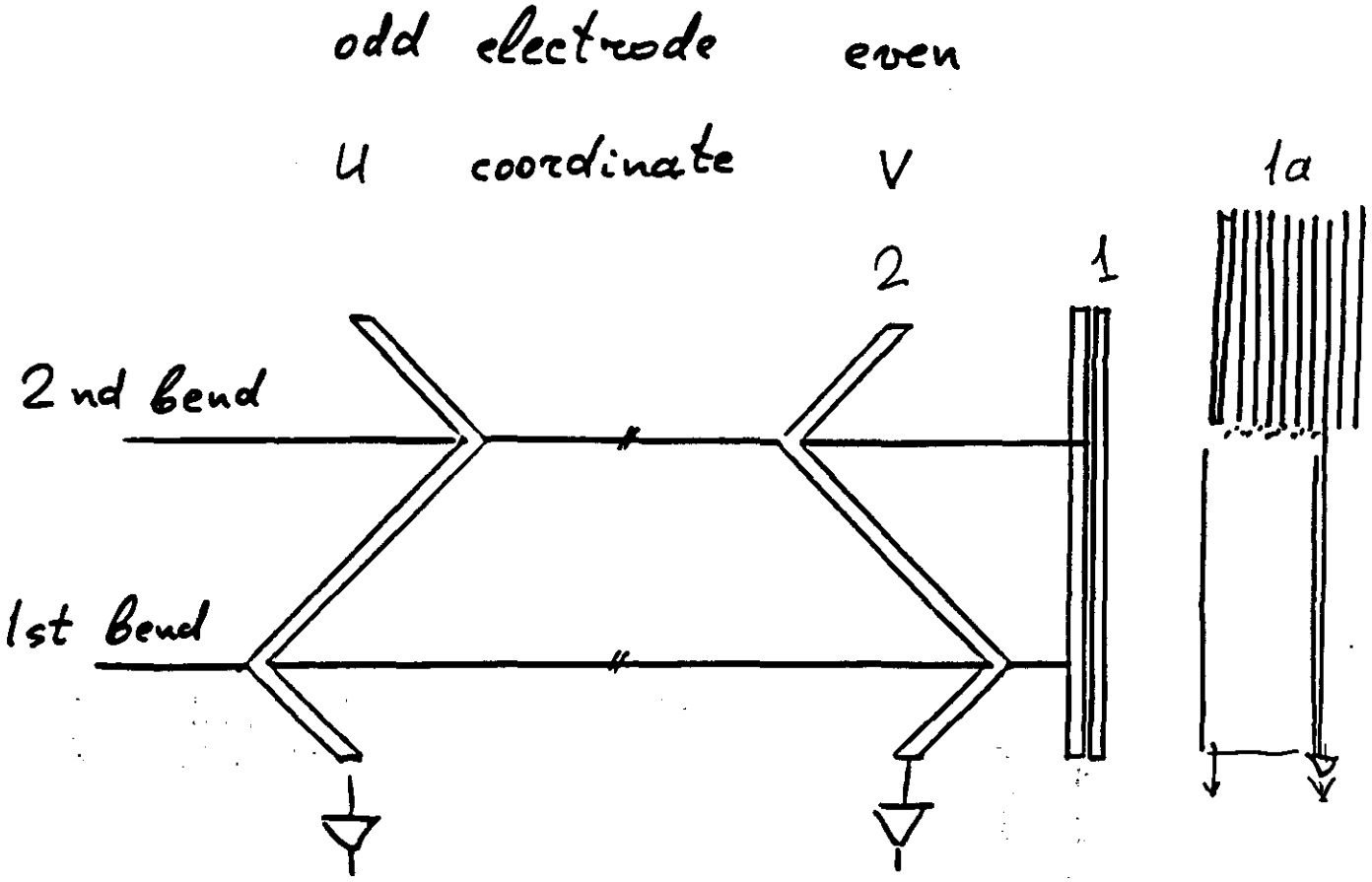
2a) U, V strips
after short 1st floor

3) Seman:

gap in accordion mechanical structure
θ, φ strips + massless gap



Plan view

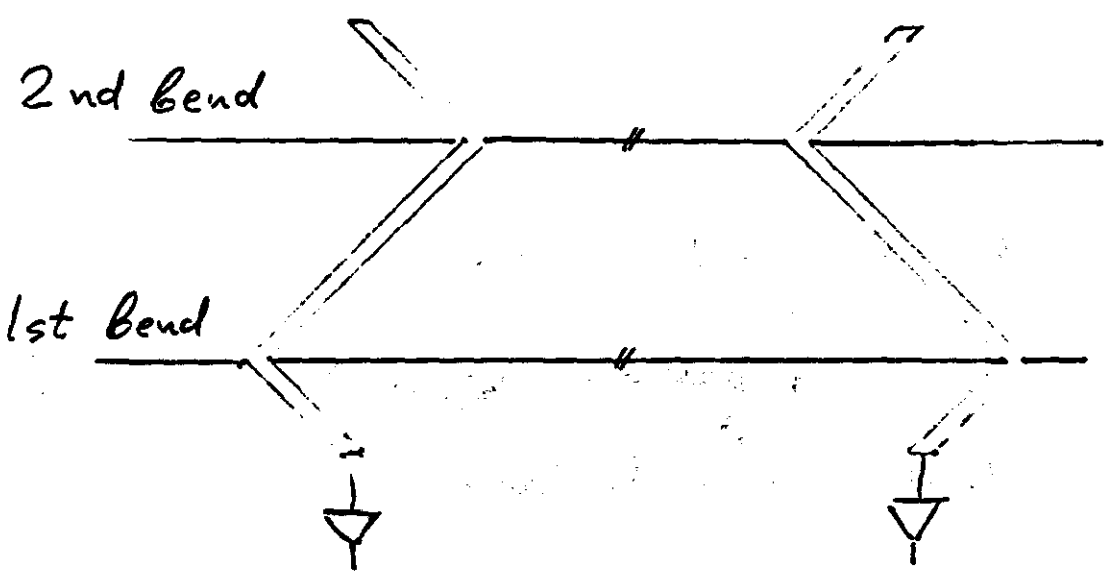


snake period = accordion period

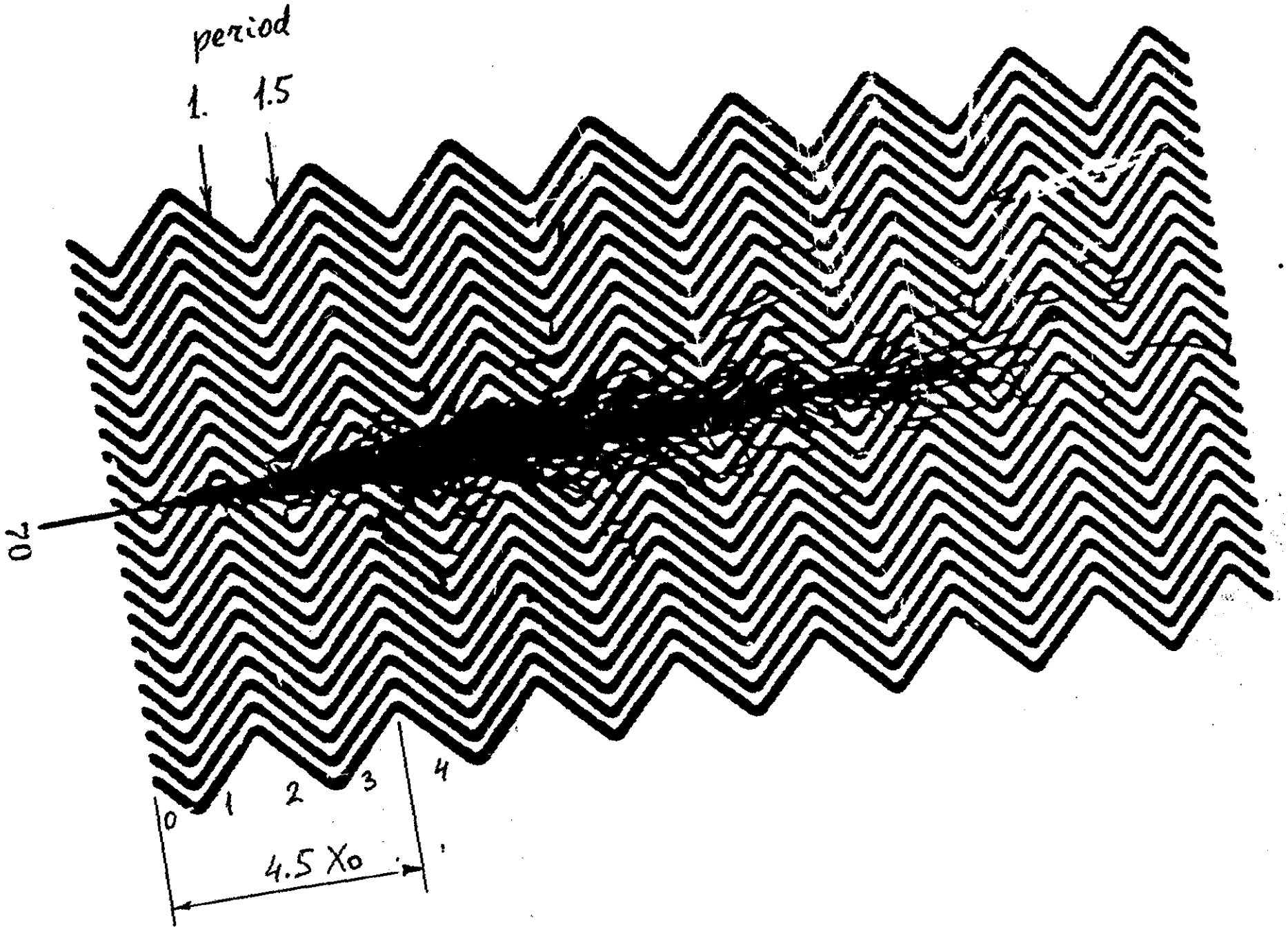
Plan view

odd electrode even

U coordinate V



snake period = accordion period


period
1.
1.5
70
0
1
2
3
4
4.5 Xo

U, V strips noise 10 MeV/strip

π^0 acceptance at 90% γ acceptance (efficiency)

θ \ E, GeV	25	25 without noise	75	100
90°	30%	17%	42%	40%
45°	30%	18%	23% (28% 1 period)	24%

suppression factor 2.5 ÷ 4

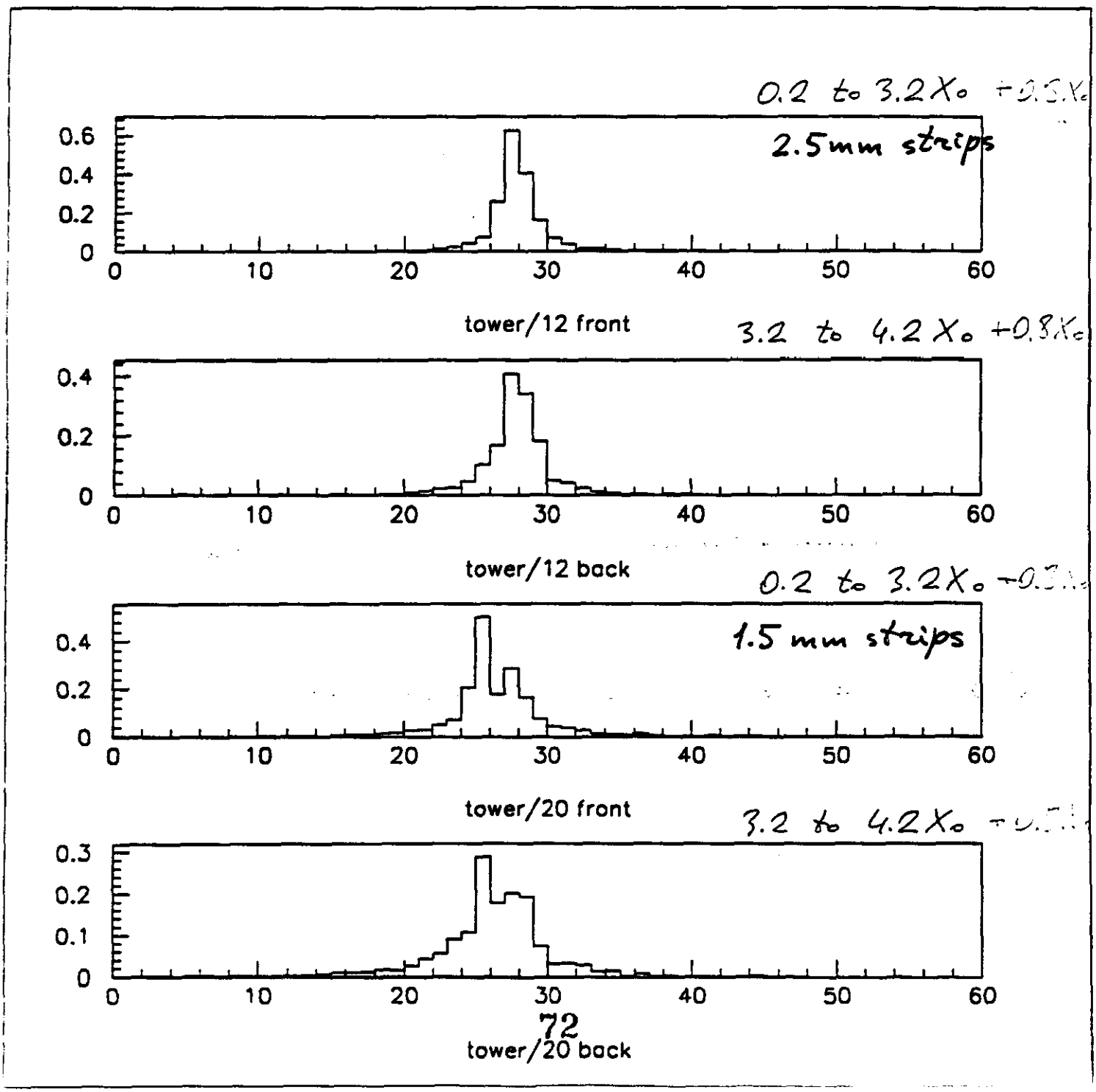
π^0 acceptance at 85% γ acceptance (efficiency)

θ \ E, GeV	25	75	100
90°	25%	35%	30%
45°	22%	20% (25% 1 period)	20%

suppression factor 3 ÷ 5

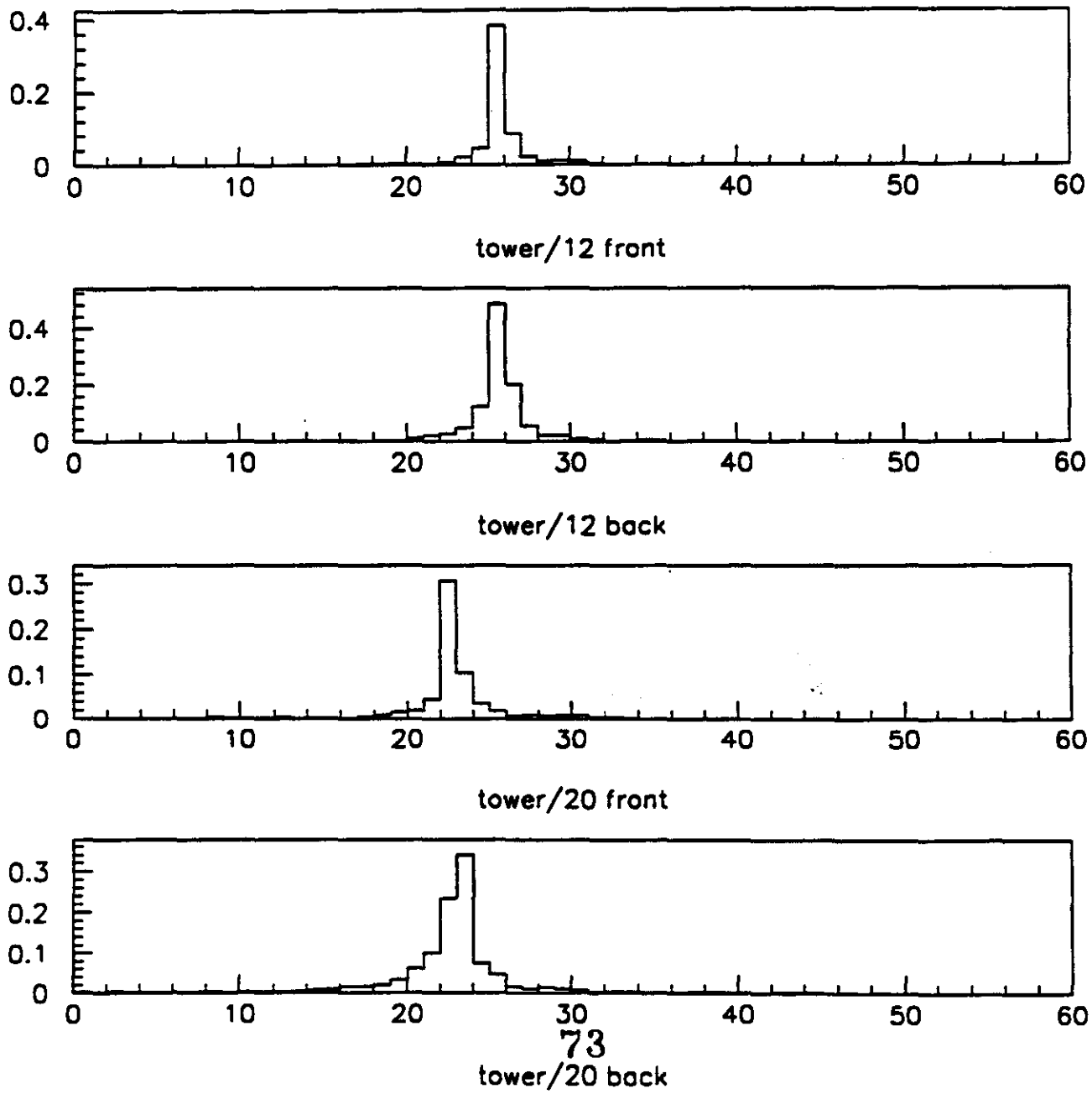
π^0 75 GeV

event 1



γ 75 GeV

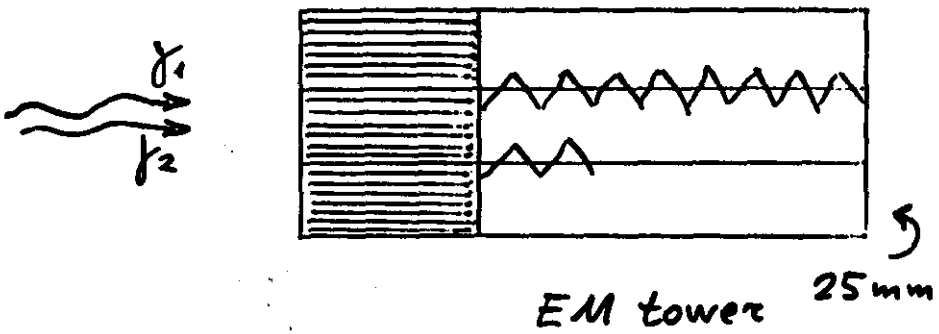
event 1



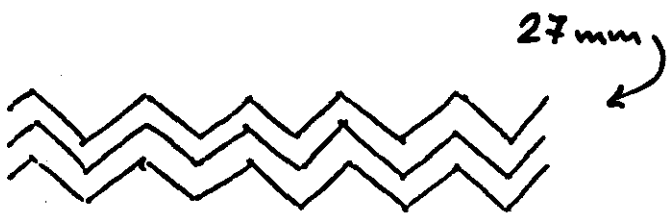
$\gamma \leftrightarrow \pi^0 \to 2\gamma$

1st section - minislices

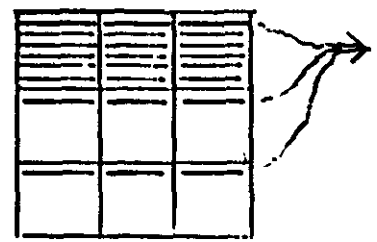
2nd section - shevron



EM tower



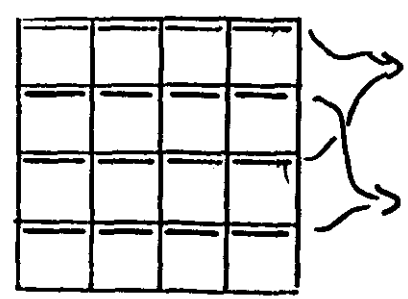
1 tower → 9 minitowers



1 preamp. for 9 minitowers

the same total number of channels

1 tower → 8 minitowers



1) parameters

2) mini tower width $\gtrsim$ 1 mm ?

Presentation by:

A. Vanyashin

A. VANYASHIN
9-17-92

specification to pointing in EM calorimeter from $H \to \gamma\gamma$

Model used :

1. 80 GeV Higgs (PYTHIA)
2. FASTI EM calorimeter

$$\underbrace{\frac{\Delta E}{E} = \frac{5.5\%}{\sqrt{E}} + 0.4\%}_{\Delta M \;=\; 600\,\text{MeV}}$$

3. Position resolution effects neglected
4. each γ angle smeared
5. θ_{12} corrected (for constrained fit)

K. Shmakov

$H_0 \to \gamma\gamma$ decay:

$$\frac{\delta M_{H_0}}{M_{H_0}} = \frac{1}{2}\sqrt{\left(\frac{\delta E_1}{E_1}\right)^2 + \left(\frac{\delta E_2}{E_2}\right)^2 + \left(\frac{\delta\Theta}{\tan(\frac{\Theta}{2})}\right)^2}$$

What is requied from the EM calorimeter:

(1) Precise *energy resolution* $\sigma(E)/E$

(2) *Angular resolution* – to measure the angle Θ between 2γ. (If vertex is unknown)

(3) *Position resolution* – contribute to angular resolution. (If vertex is known)

Ren-yuan Zhu and Hiro Yamamoto

Intermediate Mass Higgs Searches with GEM Detector

3.5 Effect of Position Resolution

It is also interesting to see the effect of shower position resolution. Table 7 shows the ratio of H→ $\gamma\gamma$ peak width as a function of the shower position resolution (δx) and energy resolution (a and b), for Higgs mass of 80 GeV. The numbers in the table are normalized to the case of a = 2, b = 0.5 and $\delta x = \delta y = 1$ mm. It is clear that the shower position resolution of an order of few mm will not compromise the discovery potential of a precision EM calorimeter.

Table 7: Ratio of H→ $\gamma\gamma$ Peak Width as Function of δx, a and b.

δx (mm)		0.5	1.0	1.5	2.0	2.5	3.0
a=2	b=0.5	0.97	1.0	1.0	1.1	1.1	1.2
a=5.5	b=0.5	1.5	1.5	1.5	1.6	1.6	1.6
a=7.5	b=0.5	1.9	1.9	1.9	1.9	2.0	2.0
a=15	b=3.7	3.8	3.8	3.8	3.8	3.8	3.8

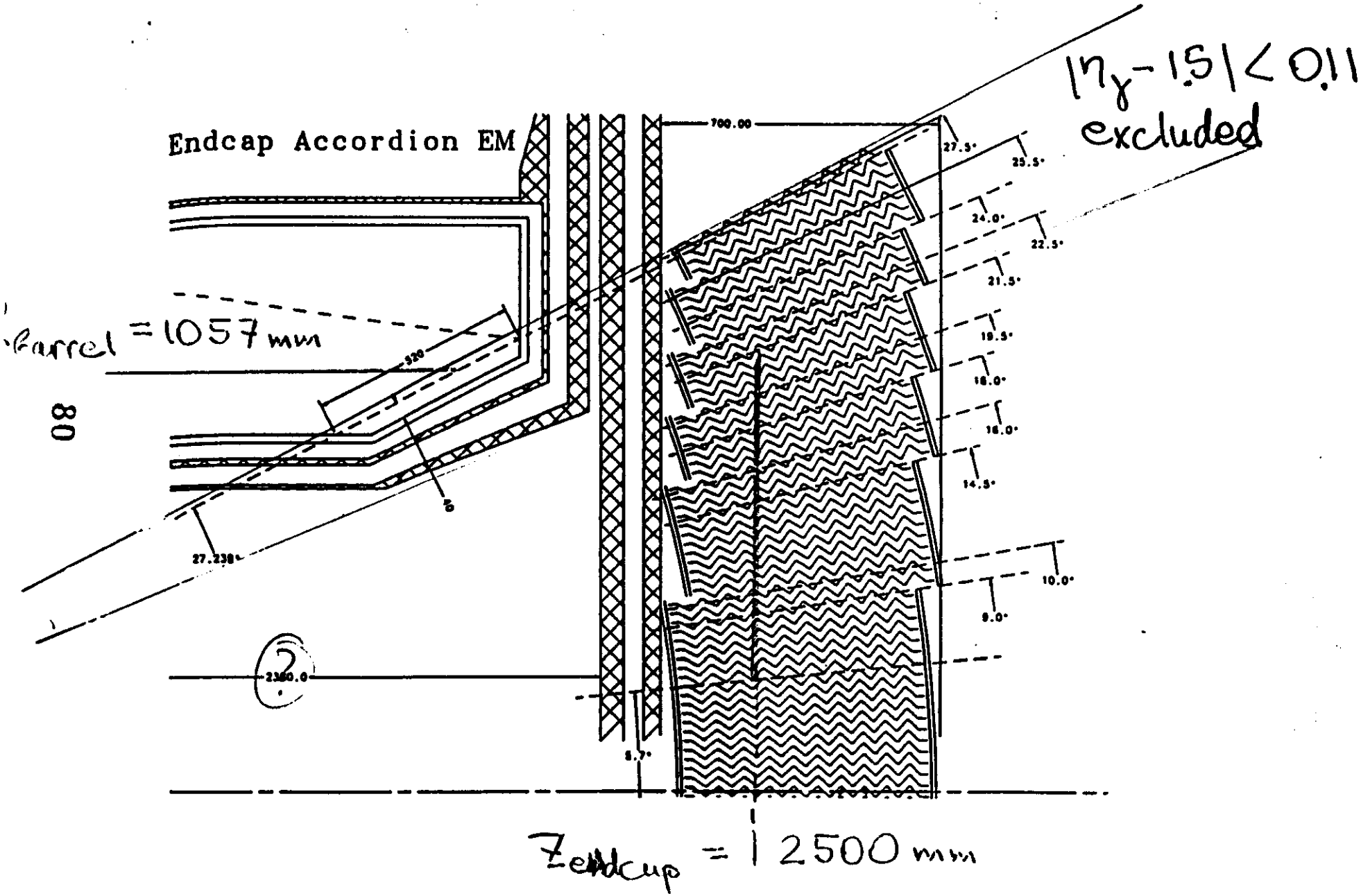
negligible

3.6 Effect of Vertex z Resolution

Table 8: Ratio of H→ $\gamma\gamma$ Peak Width as Function of δz, a and b

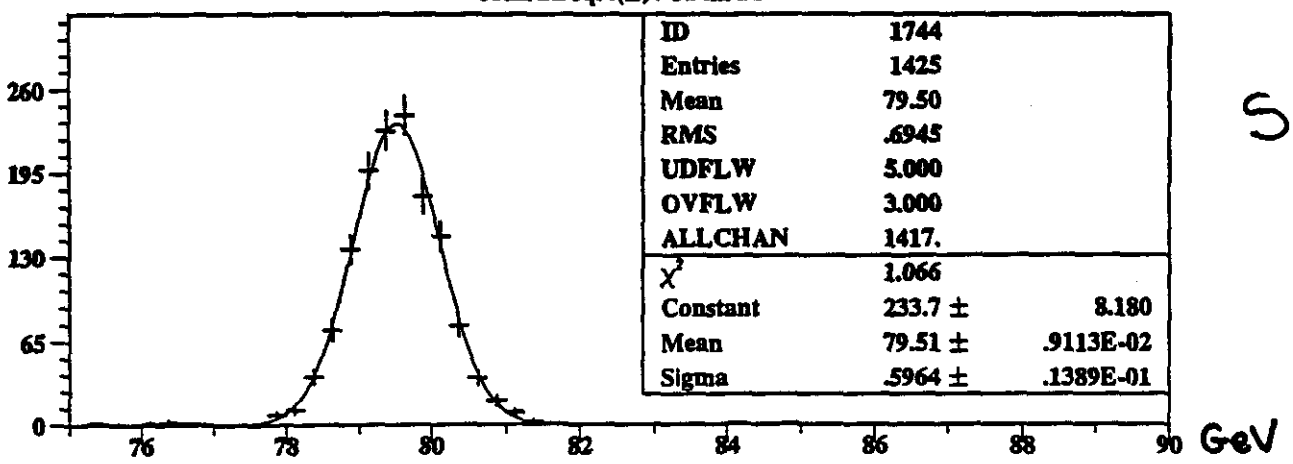
δz (mm)		1.0	2.0	3.0	5.0	10.	50.
a=2	b=0.5	1.0	1.0	1.1	1.1	1.5	5.4
a=5.5	b=0.5	1.5	1.5	1.6	1.6	1.9	5.5
a=7.5	b=0.5	1.9	1.9	1.9	2.0	2.2	5.6
a=15	b=1.0	3.8	3.8	3.8	3.8	3.9	6.5

?


Endcap Accordion EM
$|\eta_\gamma - 1.5| < 0.11$
excluded
barrel = 1057 mm
700.00
320
27.238°
2380.0
8.7°
27.5°
25.5°
24.0°
22.5°
21.5°
19.5°
18.0°
16.0°
14.5°
10.0°
8.0°
z_{endcap} = 12500 mm

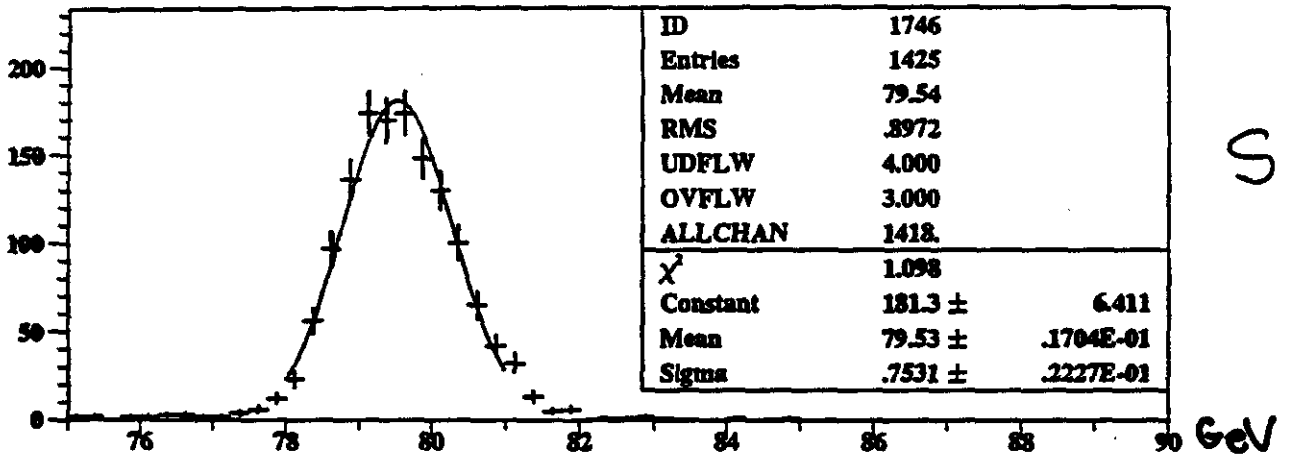
92/09/16 12.41

66mrad/sqrt(E)+ 3.9mrad



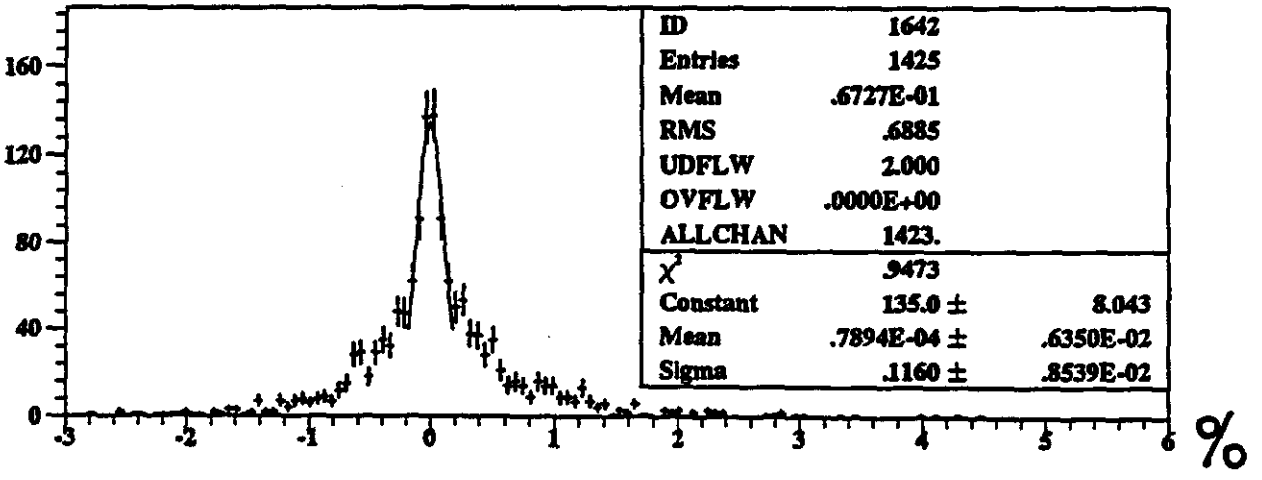
S = 1

mass of GG before sm



S = 0.87

mass of GG smeared

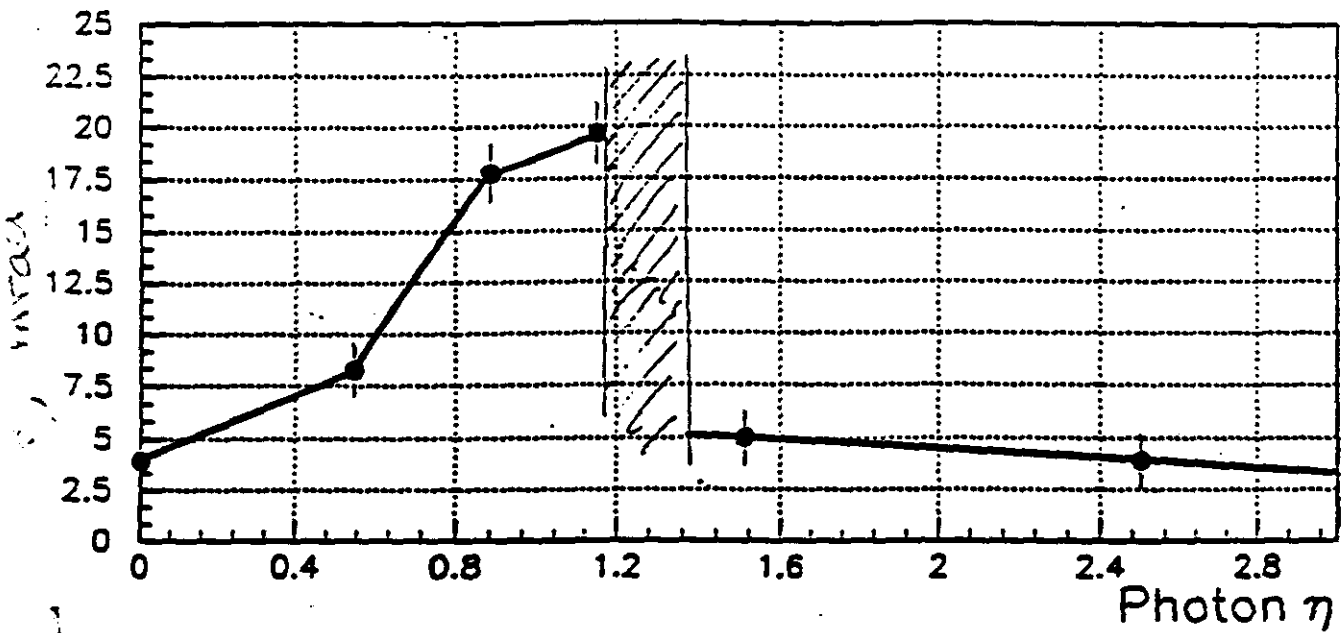


error from TH12 to M

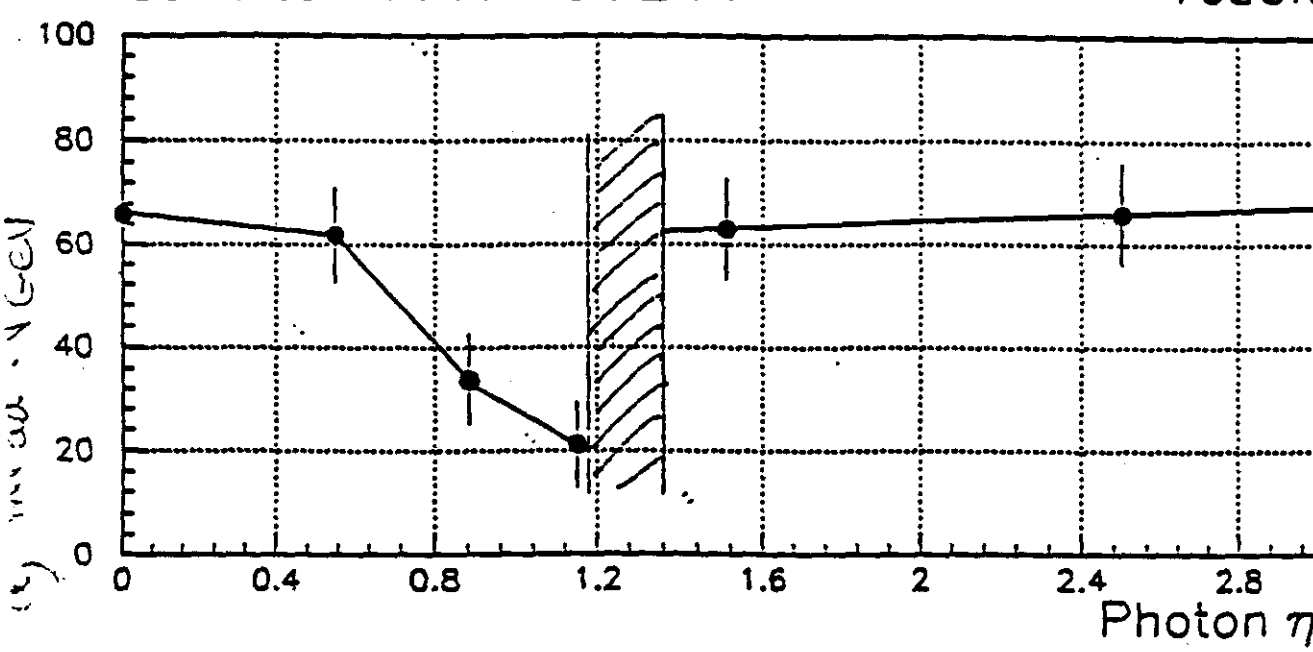
$$\frac{1}{2}\,\frac{\Delta\theta_{12}}{\tan\frac{\theta_{12}}{2}}$$

Kostya Shmakov

Constant term in ANGULAR resolution



Stochastic term in ANGULAR resolution



Preliminary!

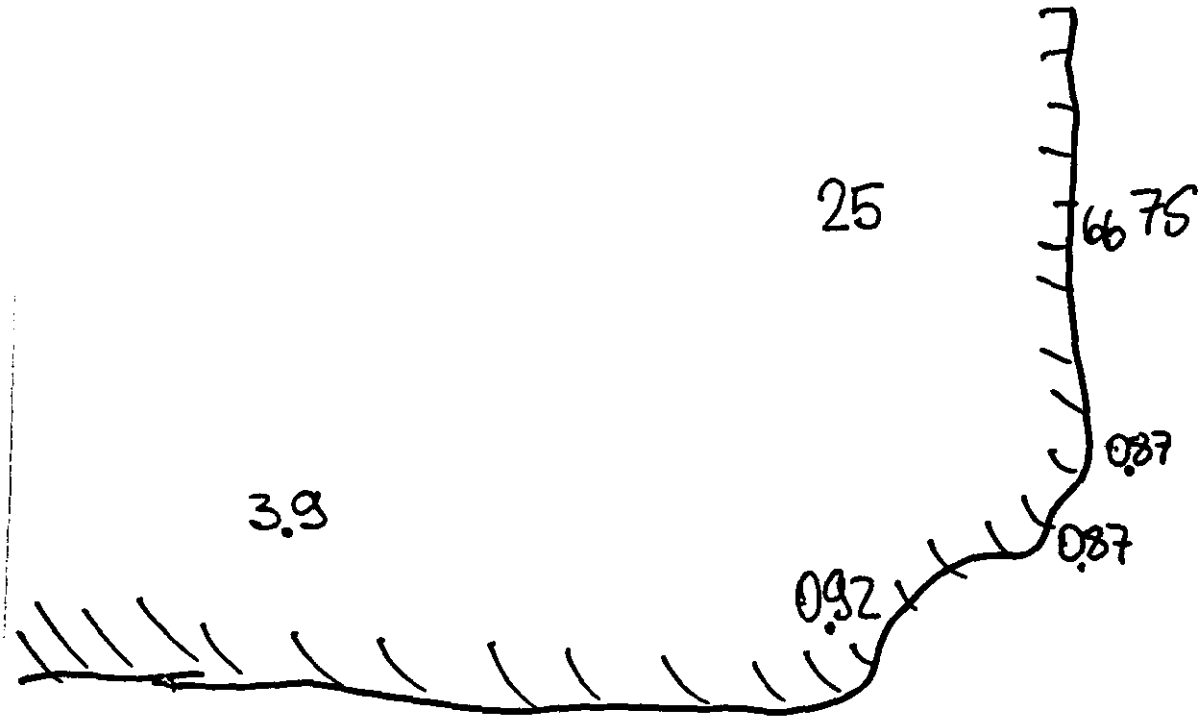
$$\Delta\Theta = \frac{a}{\sqrt{E}} + b$$

Rel. Significance of 80 GeV Higgs

b, mrad \ a, mrad·$\sqrt{\text{GeV}}$	0	50	100
0	1	0.93	0.81
5	0.94	0.89	
10	0.85		

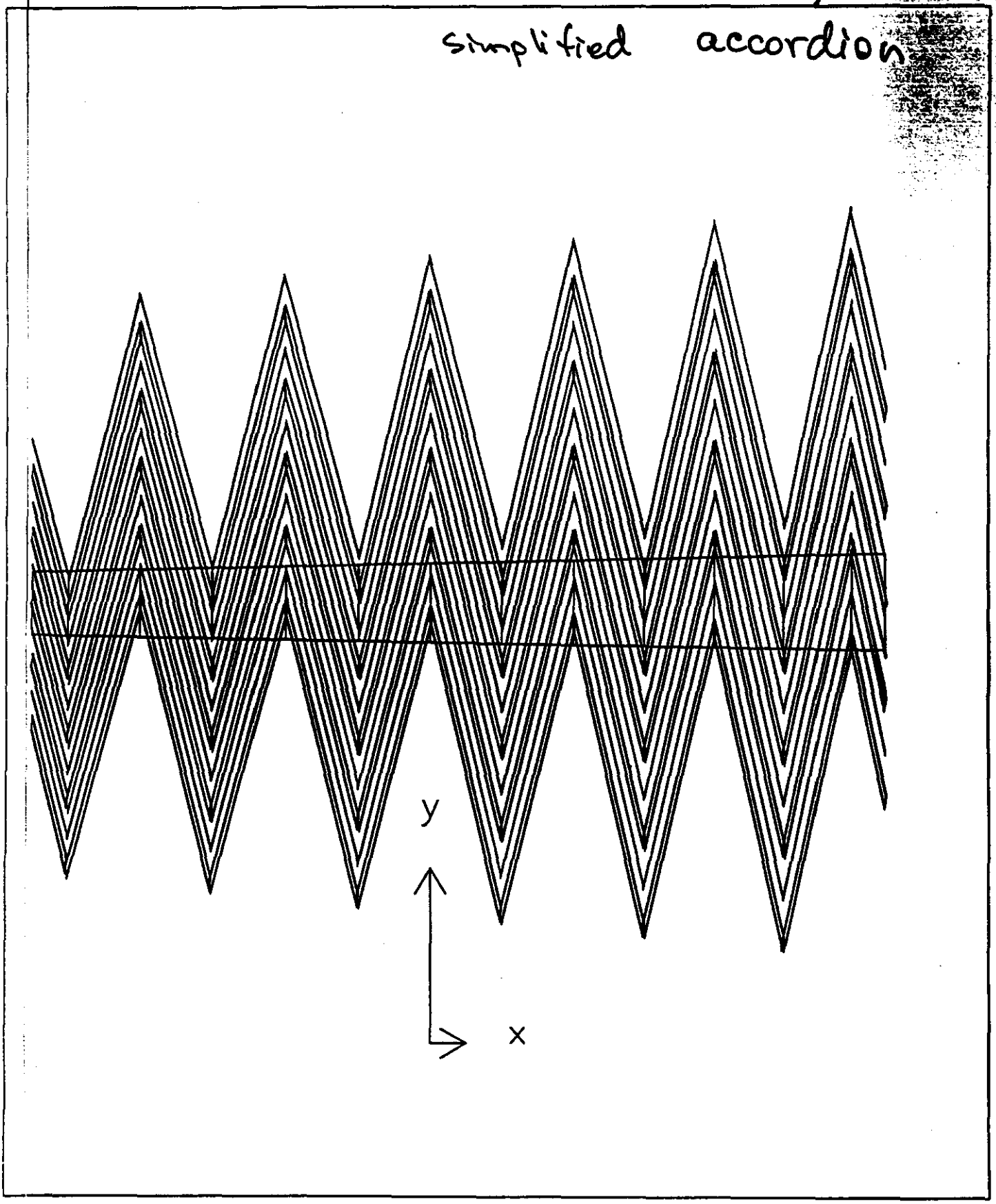
ideal pointing:
$\sigma_{Higgs} = 600$ MeV

Specification:
not more than 0.9 degradation
in Significance



Yuri Fisyak

simplified accordion



gem

γeμ

Presentation by:

K. Shmakov

π^0 rejection

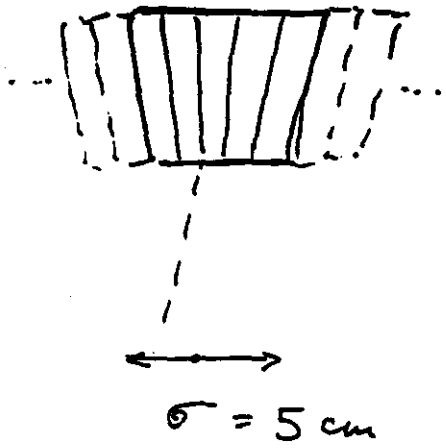
using shape analysis

ONLY

with Pb/LKr E-M calorimeter:

$$\Delta\eta \times \Delta\varphi = 0.032 \times 0.032$$

π^0 rejection in LKr



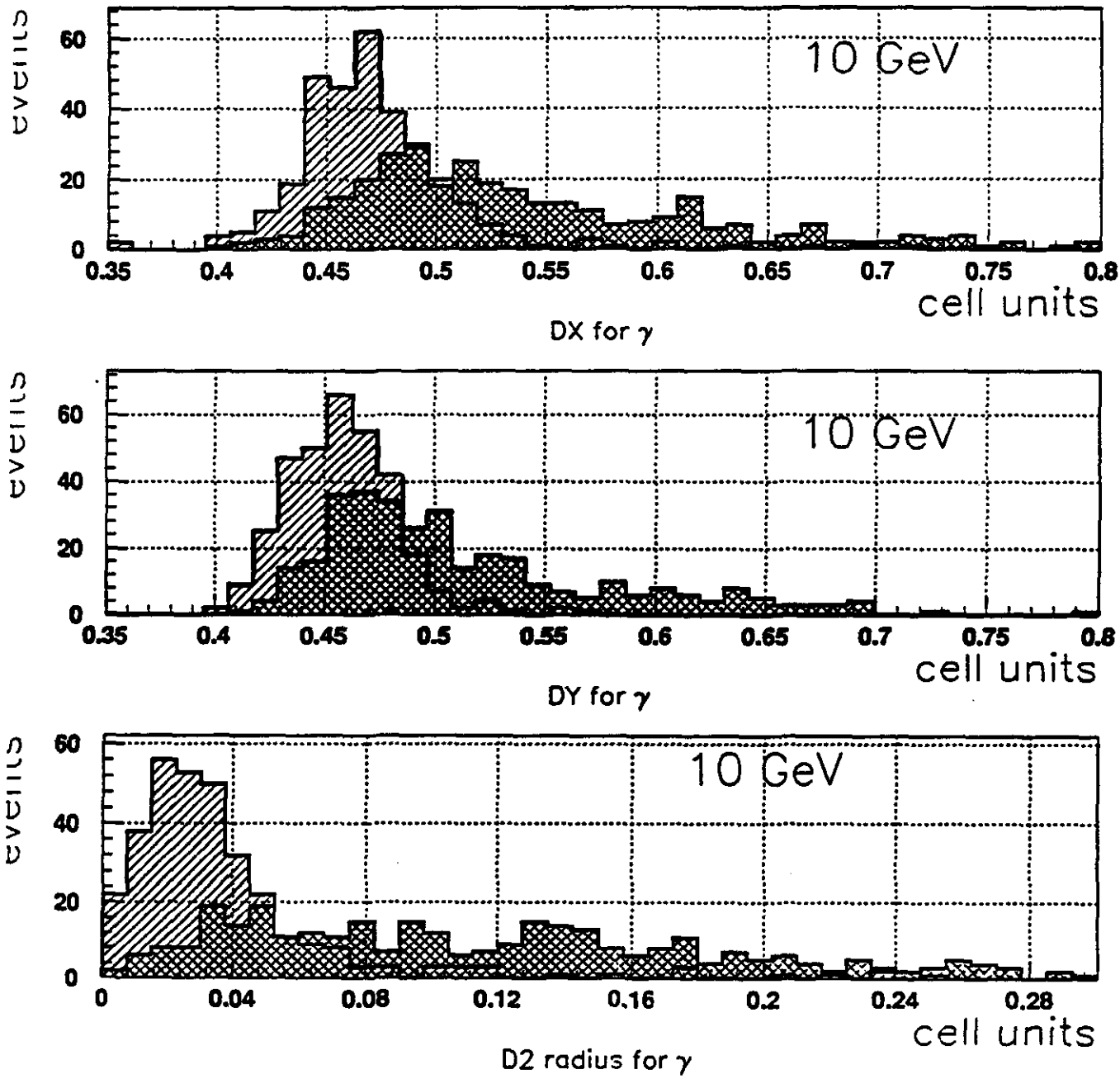
- $\sigma_{vertex} = 5$ cm
- GEANT 3.15, $25 X_0$ Pb/LKr calorimeter with $\Delta\eta \times \Delta\varphi = 0.032 \times 0.032$
- Matrix 5×5 cells was used for analysis (original 21×21) around maximum.
- Different cuts:

used for presentation:
- + D_x (1)
- + D_y (2)
- + $D2$ (3)

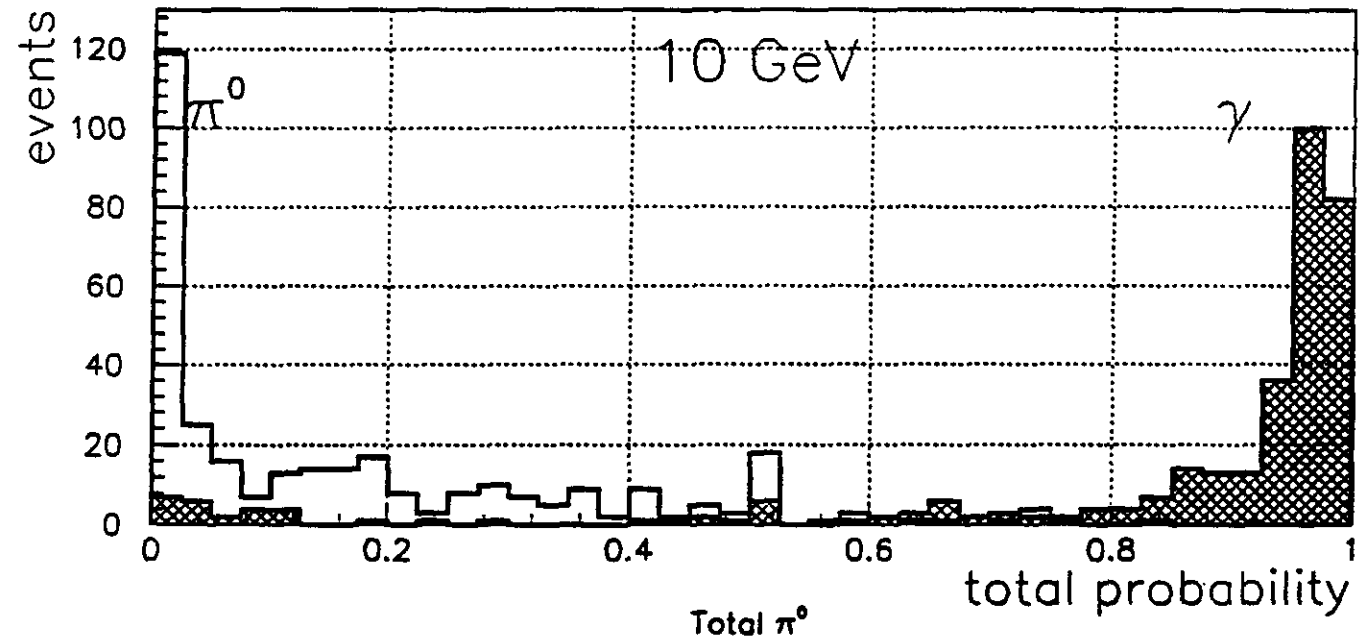
Not used, available:
- − Assymmetry (min/max)
- − Pointing error $(X_F - X_B)$
- − readout from 1 cm of the tower.

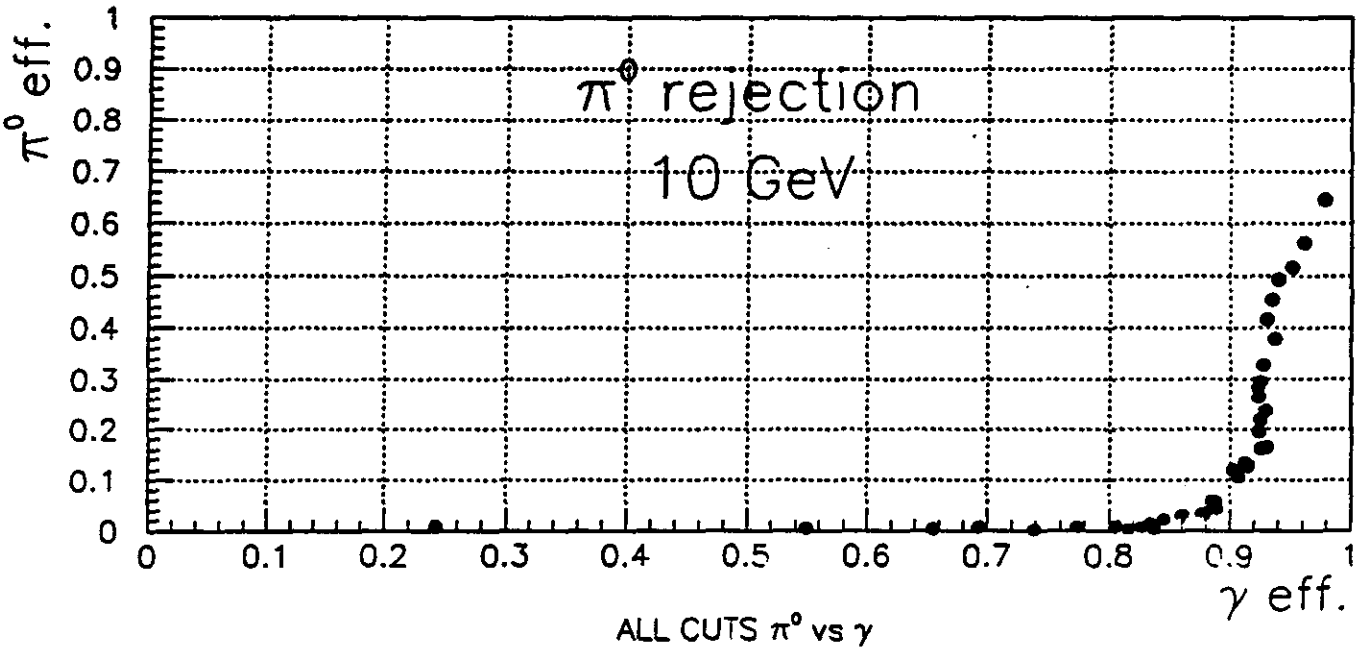
- Maximum likelihood method was used.

LKr: 3 cuts - DX,DY,Dradius

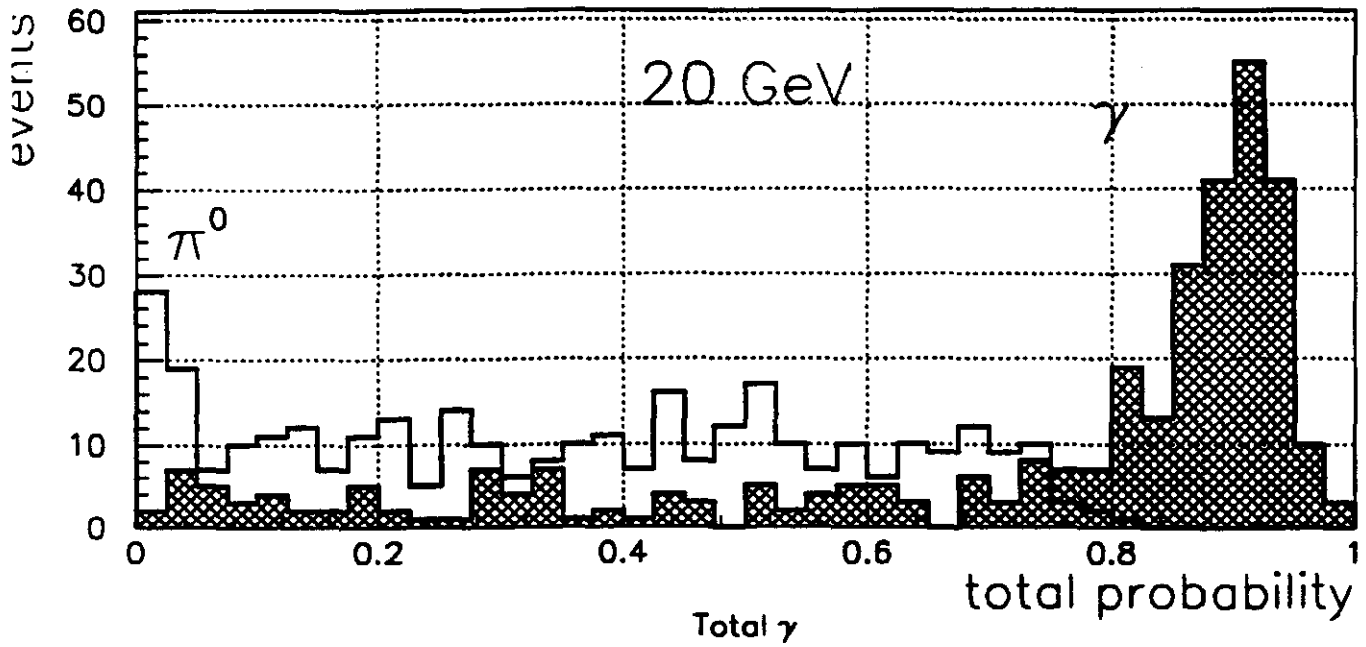


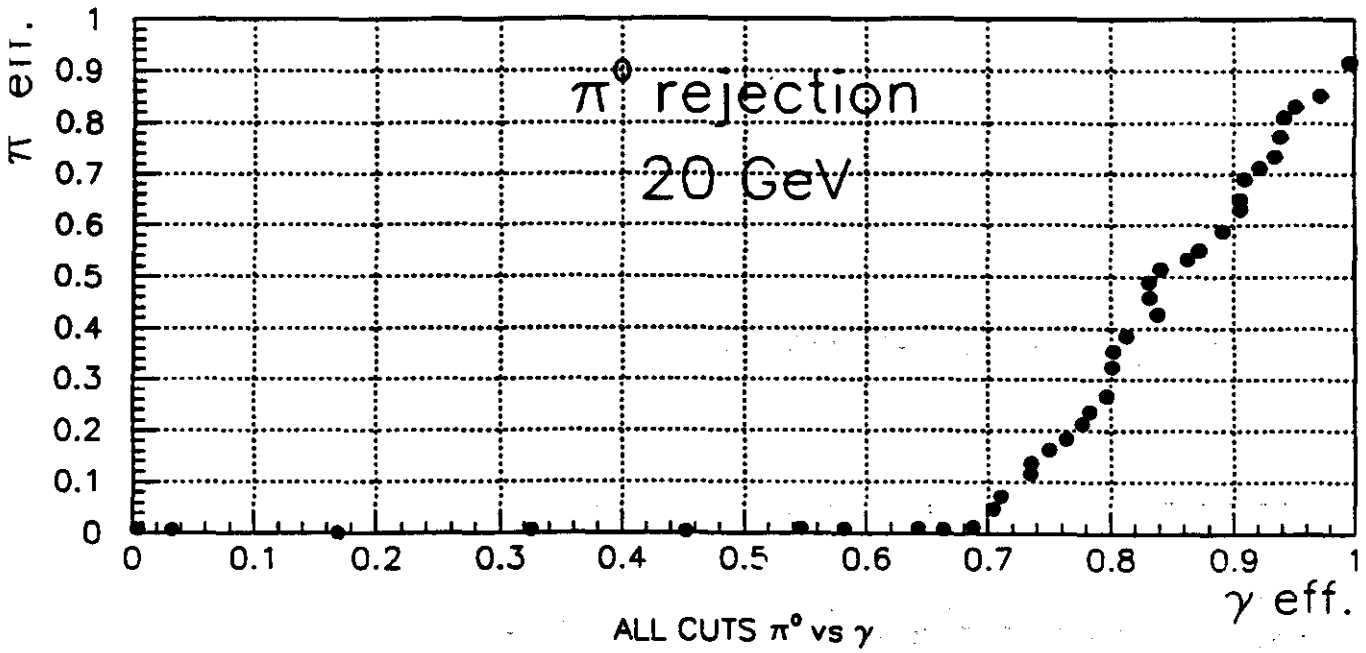
LKr: 3 cuts - DX, DY, Dradius - Likelihood method



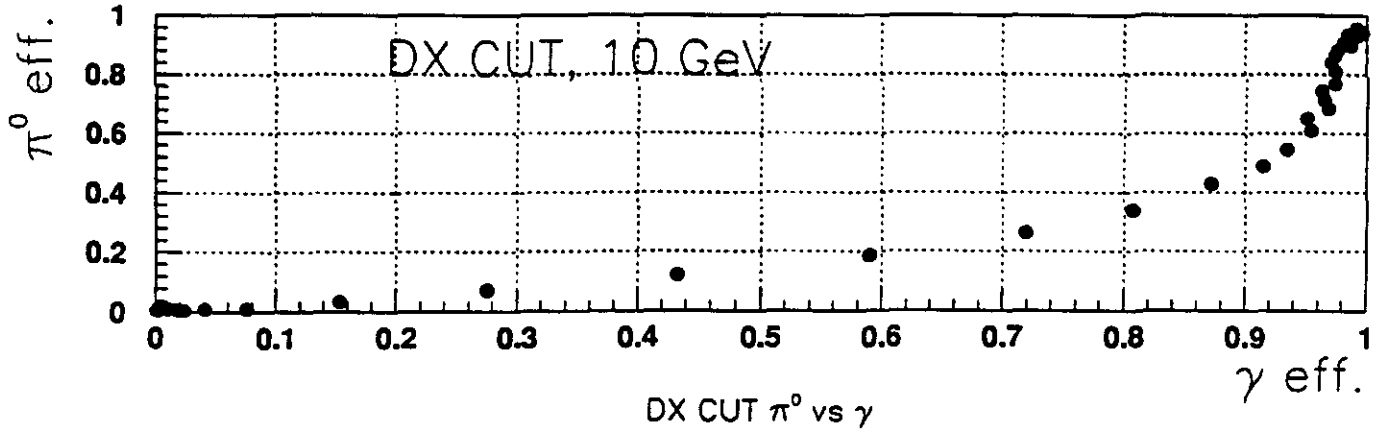


LKr: 3 cuts - DX, DY, Dradius - Likelihood method

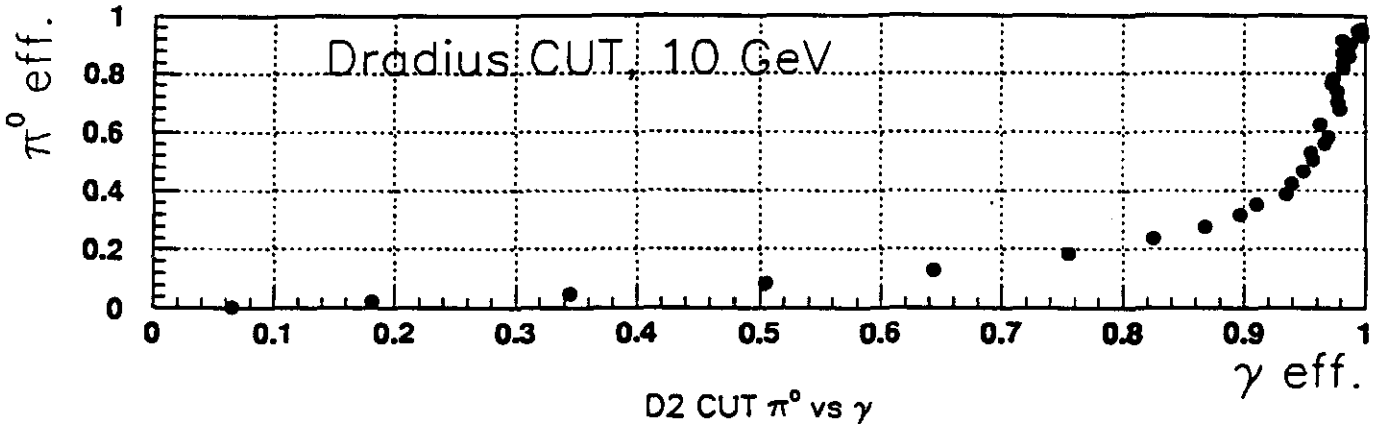




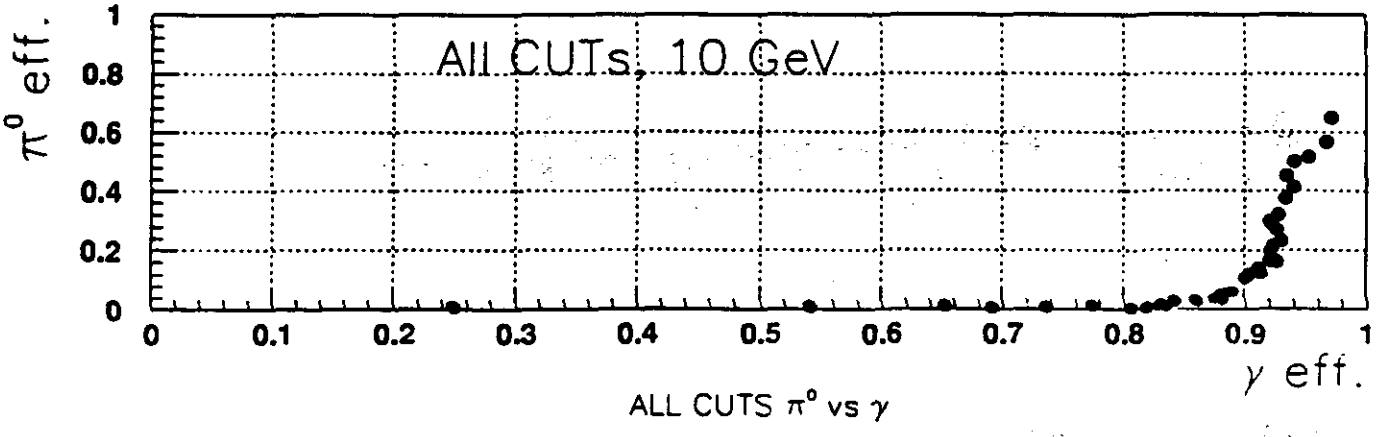
CUTS effectiveness



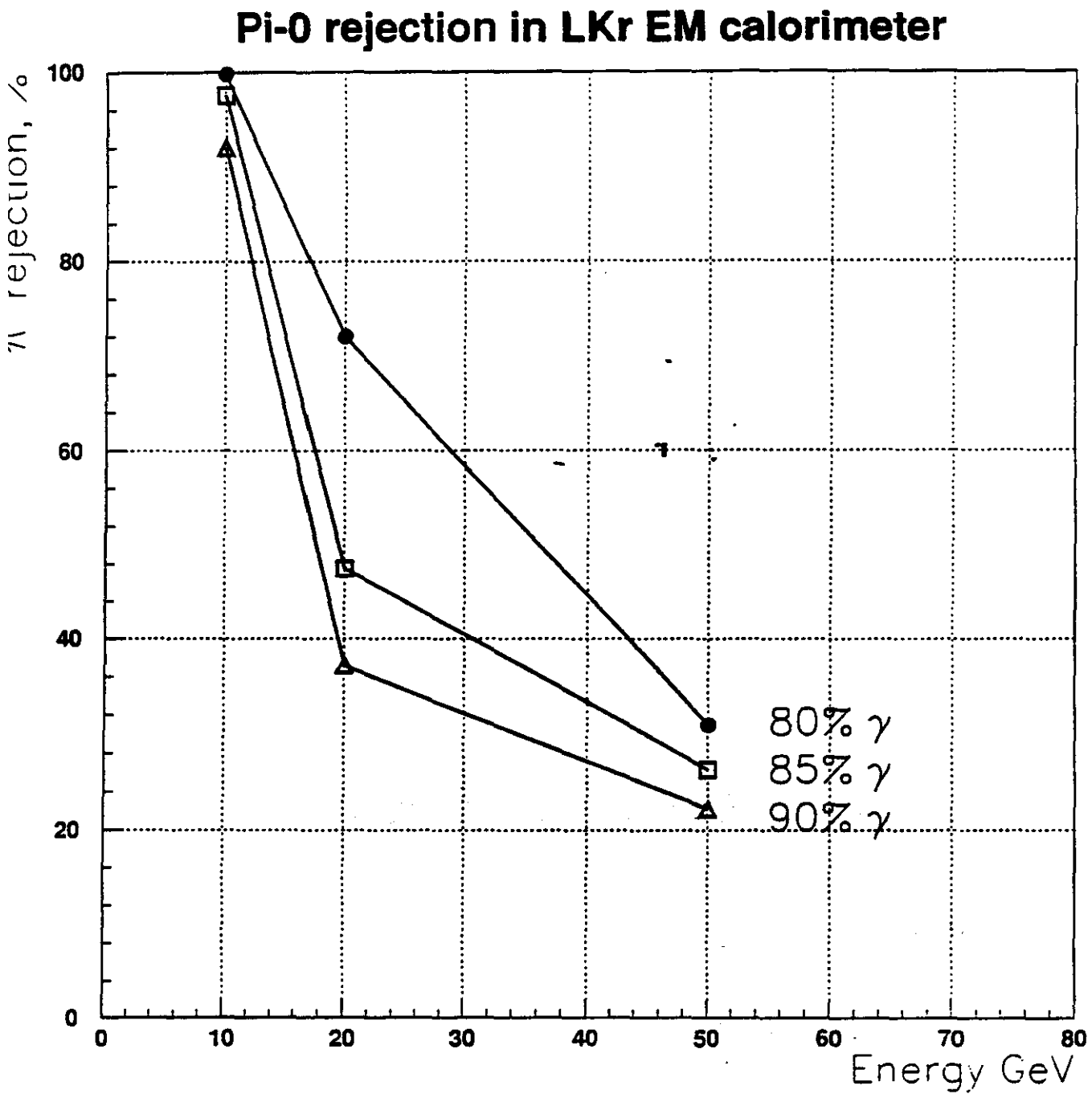
DX CUT π^0 vs γ



D2 CUT π^0 vs γ



ALL CUTS π^0 vs γ

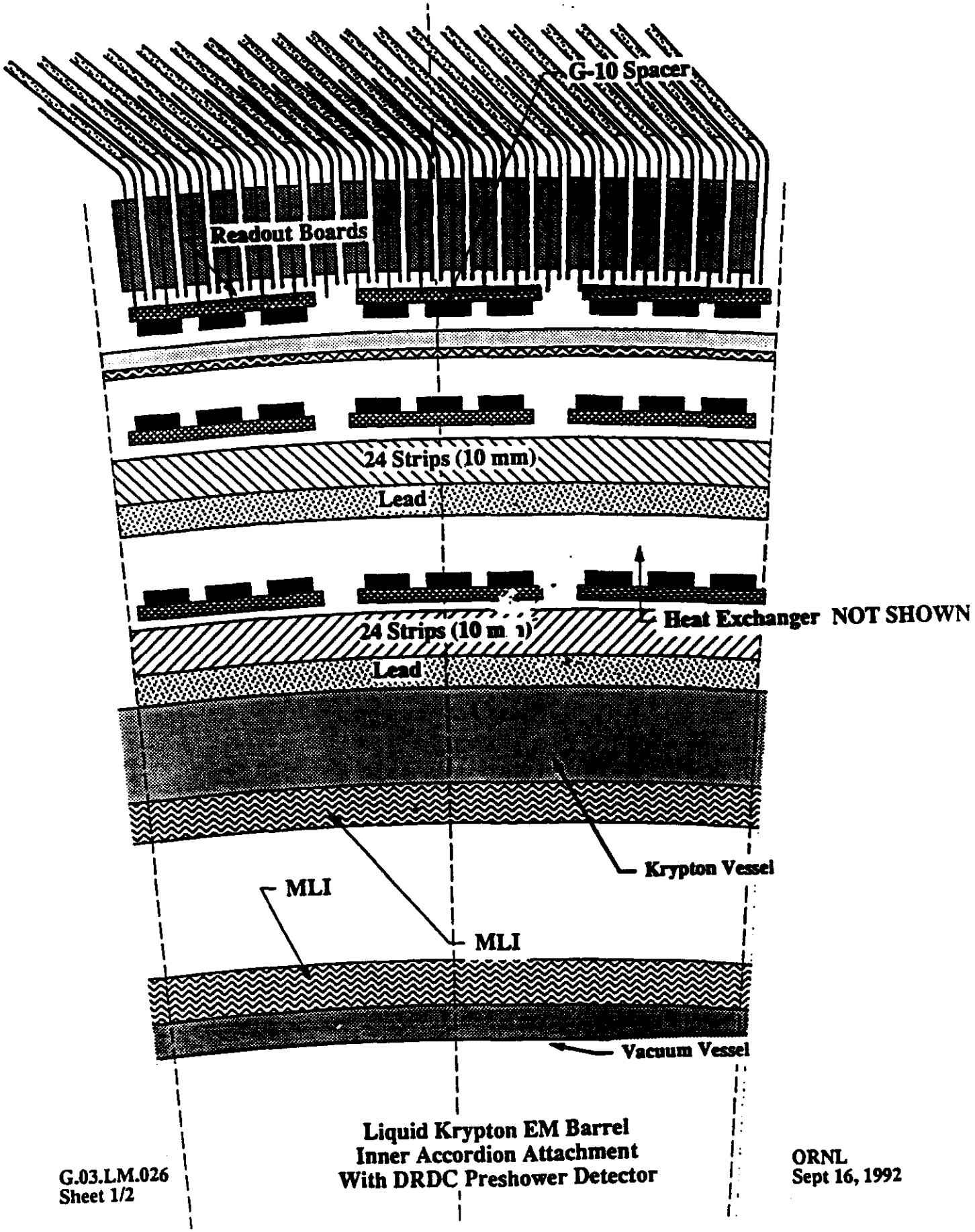

Pi-0 rejection in LKr EM calorimeter
π rejection, %
100
80
60
40
20
0
0
10
20
30
40
50
60
70
80
Energy GeV
80% γ
85% γ
90% γ

gem

γeμ

Presentation by:

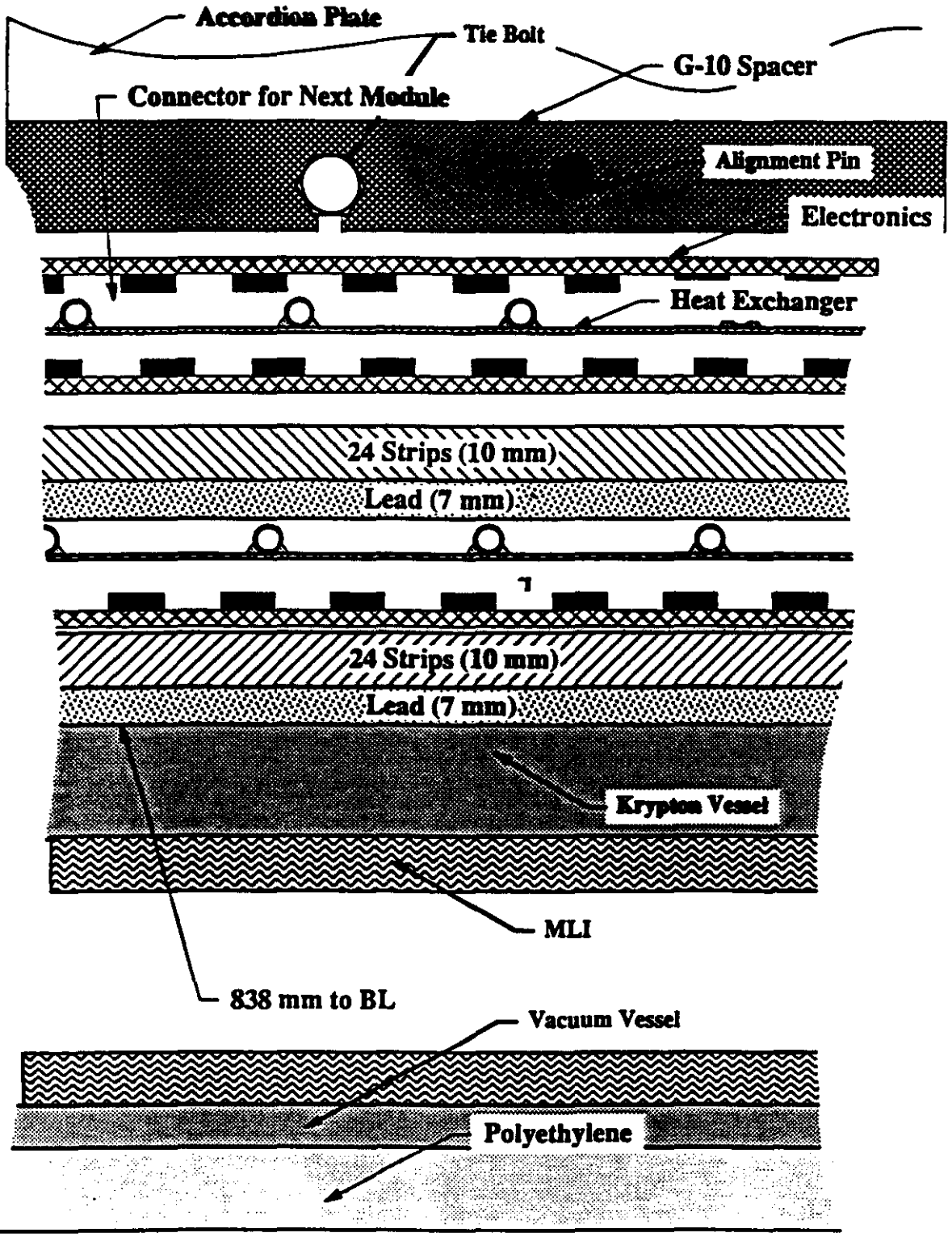
Yuri Kamyshkov



G.03.LM.026
Sheet 1/2

Liquid Krypton EM Barrel
Inner Accordion Attachment
With DRDC Preshower Detector

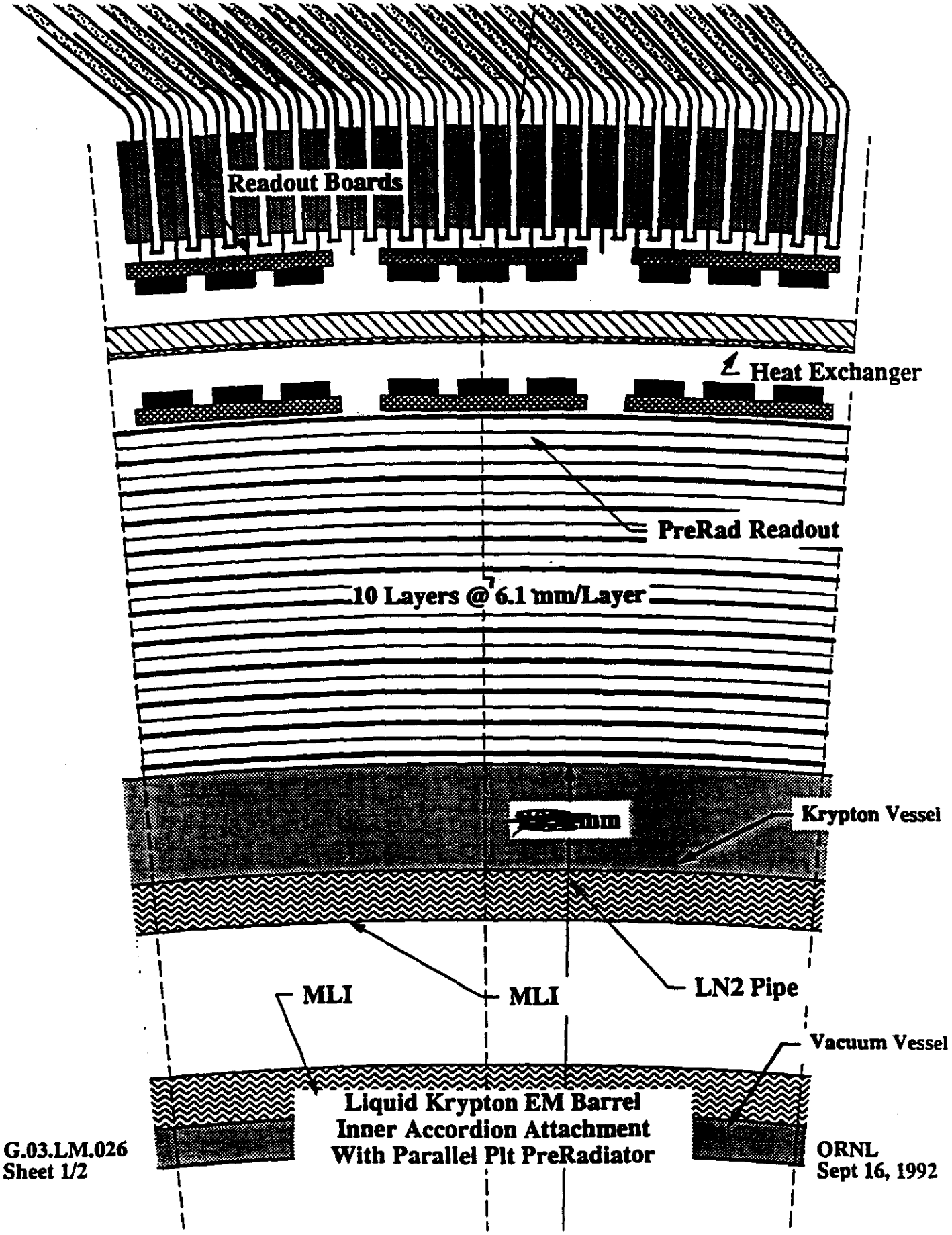
ORNL
Sept 16, 1992



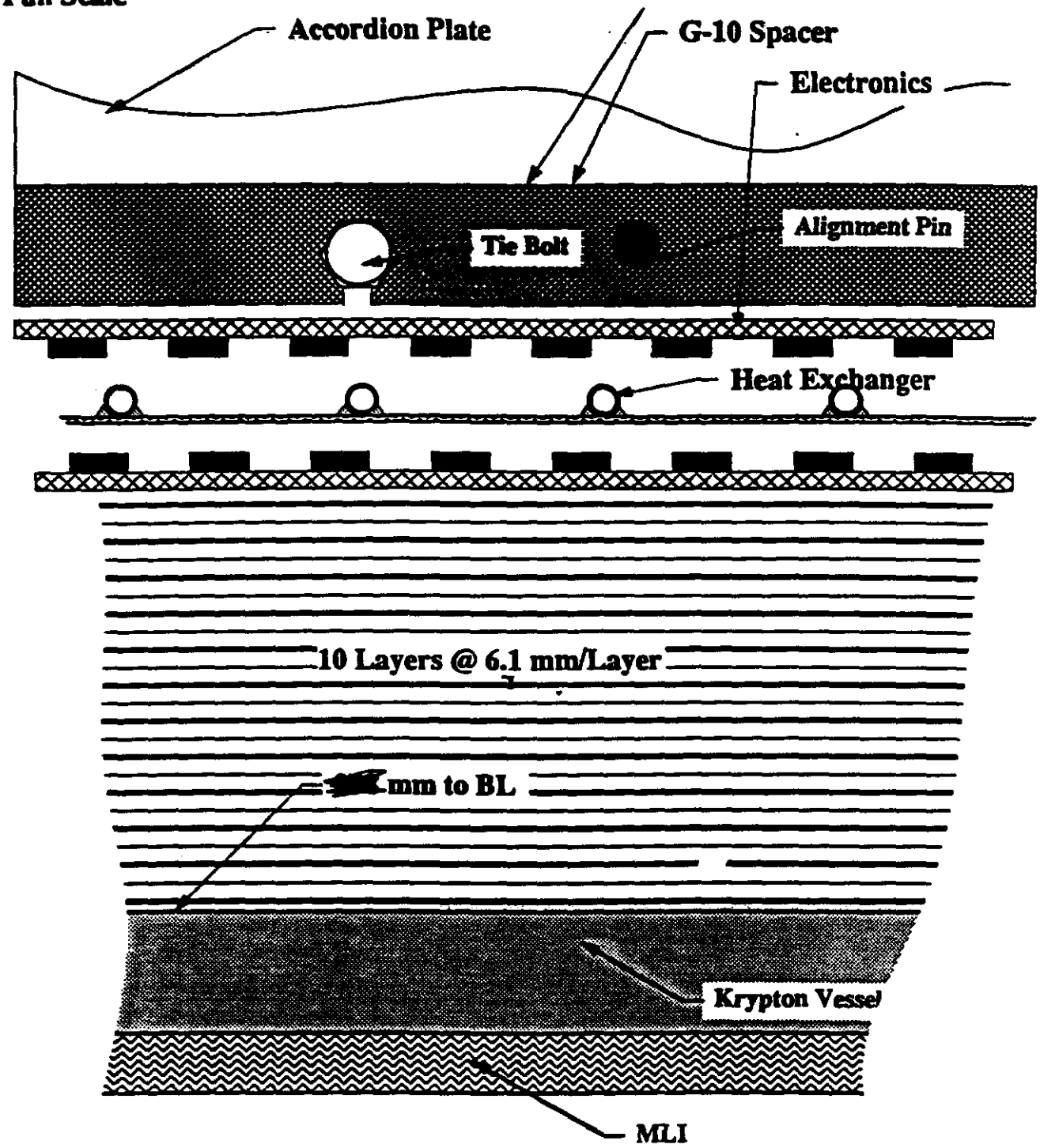
G.03.LM.026
Sheet 1/2

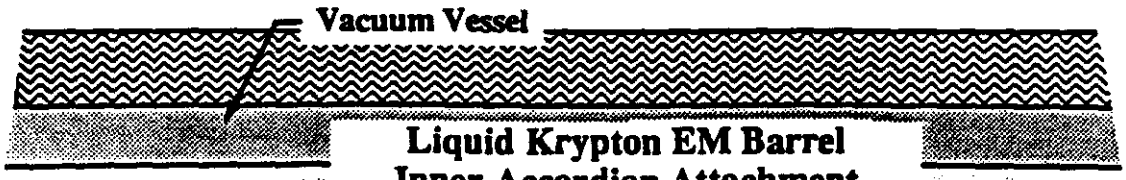
Liquid Krypton EM Barrel
Inner Accordion Attachment
With DRDC Preshower Detector

ORNL
Sept 16, 1992


Readout Boards
Heat Exchanger
PreRad Readout
10 Layers @ 6.1 mm/Layer
[redacted]mm
Krypton Vessel
MLI
MLI
LN2 Pipe
Vacuum Vessel
Liquid Krypton EM Barrel
Inner Accordion Attachment
With Parallel Plt PreRadiator
G.03.LM.026
Sheet 1/2
ORNL
Sept 16, 1992

Full Scale

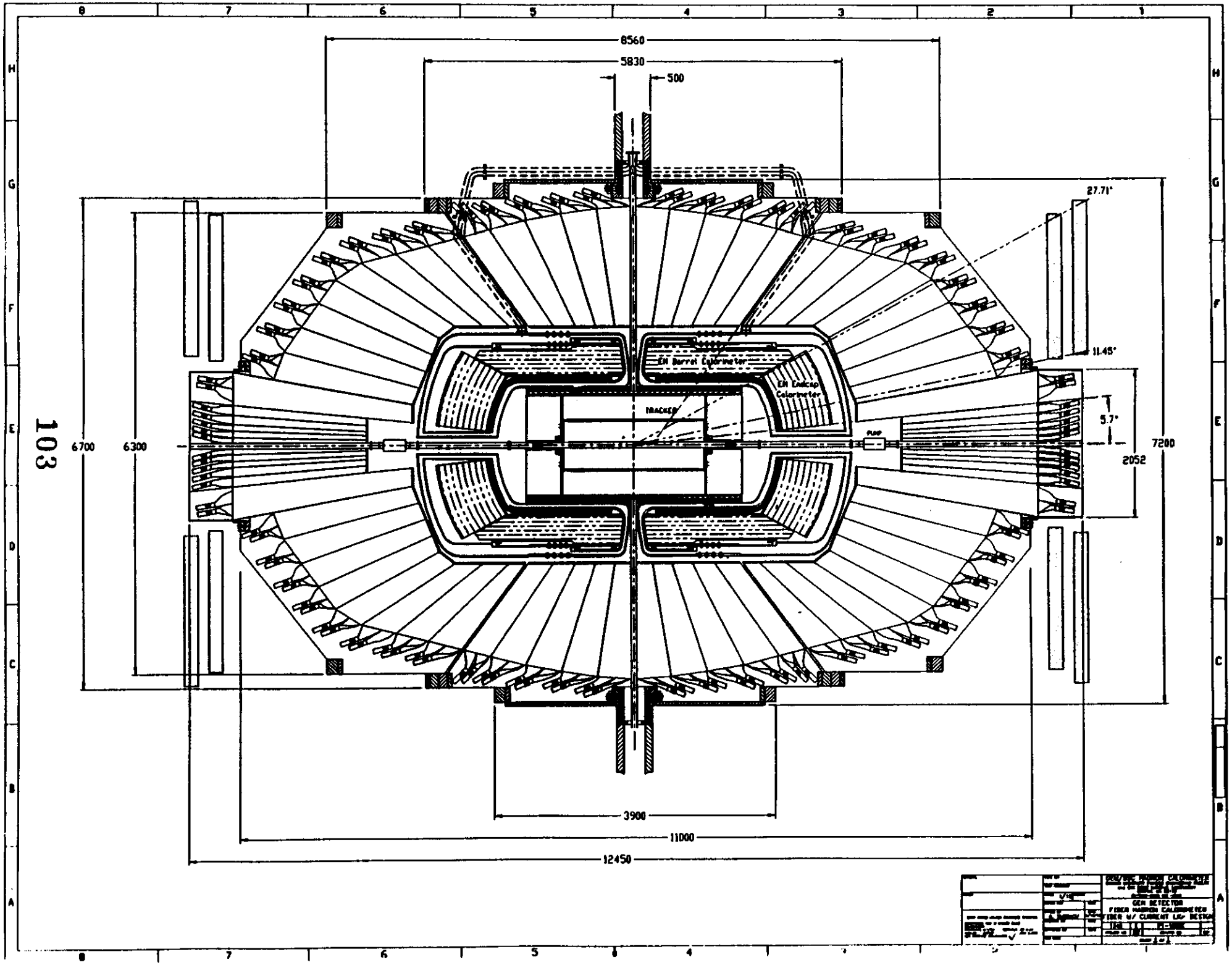


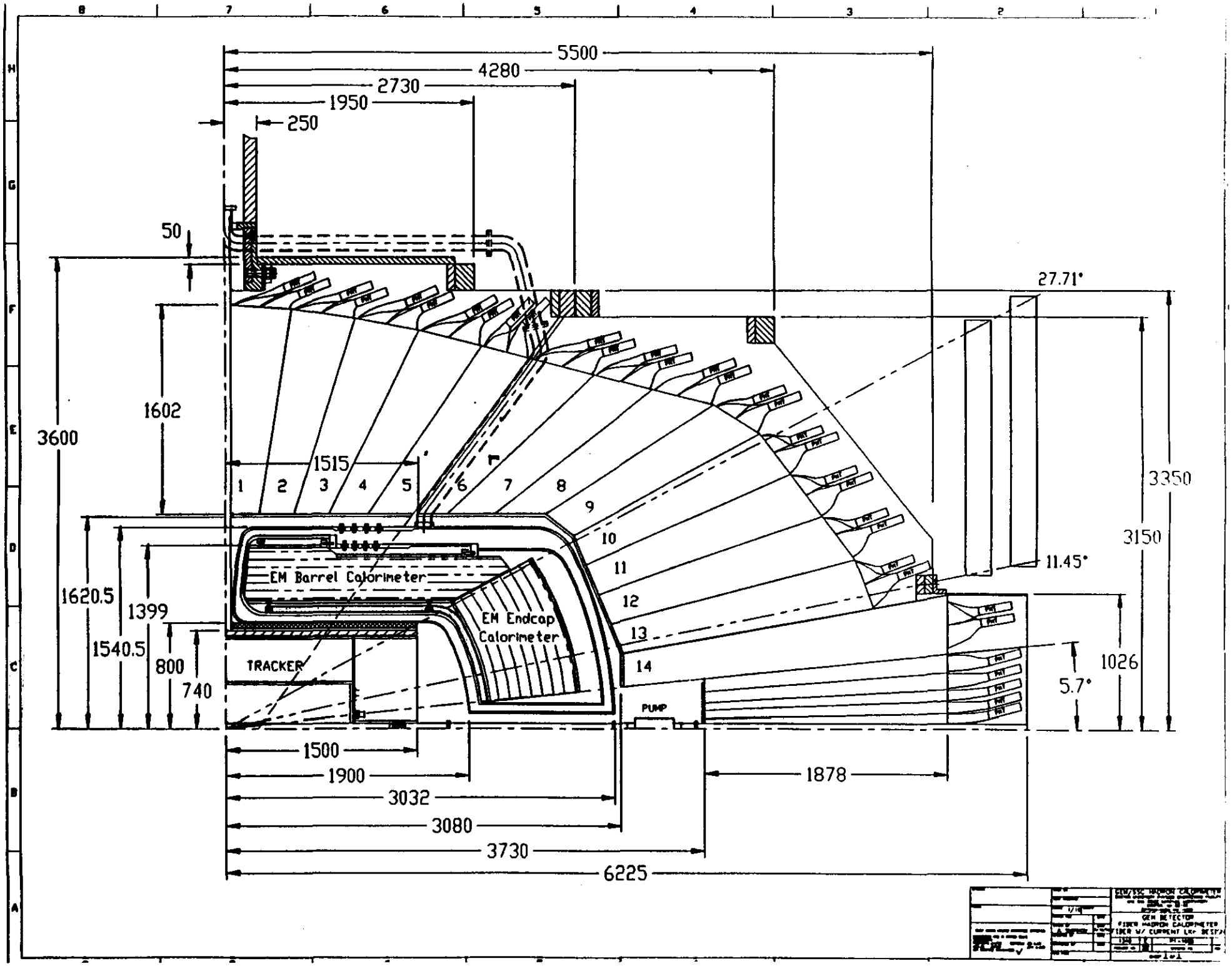


Liquid Krypton EM Barrel
Inner Accordion Attachment
With Parallel Plt PreRadiator

G.03.LM.026
Sheet 1/2

ORNL
Sept 16, 1992


8560
5830
500
27.71°
11.45°
5.7°
EM Barrel Calorimeter
EM Endcap Calorimeter
TRACKER
PLUG
6700
6300
7200
2052
3900
11000
12450


5500
4280
2730
1950
250
50
3600
1602
1515
1620.5
1399
1540.5
800
740
1500
1900
3032
3080
3730
6225
1878
1026
3350
3150
27.71°
11.45°
5.7°
1
2
3
4
5
6
7
8
9
10
11
12
13
14
EM Barrel Calorimeter
EM Endcap Calorimeter
TRACKER
PUMP