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The Mylar Straw Tubes: Test Results and Applications to Muon Tracking

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We report the test results of a 1 m long block of mylar straw tubes consisting of 64 channels. The spatial resolution and charge distribution have been obtained. The application to muon tracking of GEM are discussed.

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Abstract

We report the test results of a 1 m long block of mylar straw tubes consisting of 64 channels. The spatial resolution and charge distribution have been obtained. The application to muon tracking of GEM are discussed.

Introduction.

High precision on the muon momentum resolution is obtained in GEM by measuring in ironless magnetic volum. To minimize the influence of multiple scattering for low momentum and energy loss for high momentum of muon the light tracking detectors are required. The mylar straw tubes are a candidate for this purpose. The technology of straw tubes manifactures with diameter 5-25 mm from mylar 50-100 μm thickness are developing now [1]. The block of several tubes are forming from two sheet of foil welding by ultrasonic. This block form stiff, rigid and self supporting structure working at overpressure about 4 atm/Diameter of tube (cm). At present the 2.5 m long block from 100 μm mylar can be constructed.

The prototype of 64 tubes with 10 mm diameter and 1 m length was made for test. The foil coating of 0.1 μm Al was used. The anode wires from CuBe with diameter 50 μm were strung in common manifold plate with accuracy ± 25 μm. The gas mixture flashed parallel to tubes at rate 1 L/H.

The experimental set up.

All measurements described here were realized on the test beam of U-70. The beam was tuned for pion of 5 GeV. Per beam spill up to 40 pions passed the chamber. The setup of chamber shown on fig.1. The beam monitoring by two counter S1 and S2 fixed above wires plane. The trigger provided by counters and any four tubes. We have used two gas mixtures Ar(80)-Co2(20) and Ar(60)-Isob(40) which pumping through propanol at T=20$\pm$1°C. The electronics read out is shown in fig.2. The preamplifier has gain K=38 mV/μA, rise-time 10 ns, equivalent noise about 3000e^-. The output signals were guided to shapers and thence to TDC 2228. One channel of

preamplifier followed by charge sensitive ADC 2[illegible]

Test results.

The means efficiency excluding a trigger tubes shown on fi[illegible]. The plateau limit for Ar-Co2 mixture has determined by Geiger mode arising at U=2.3 kV. The lower efficiency for Ar-C02 as compared with Ar-Isob probably connect with larger charge fluctuation. In fig.4 charge spectra in proportional mode for both gas mixture are displayed. The streamer mode arose at U=2.7 kV for Ar-Isob mixture, as can be seen from fig.5. The peculiarity of streamer is smaller charge fluctuation. The $\Delta q/q$ dependence from high voltage illustrates this fact on fig.6.

In order to study the spatial resolution the tracks traversing tubes were fitted by straight line. The coordinate i-tube can be given by the expression:

X_i=V(t_i-t_{io})[illegible]$_i$-t_{io}),

here t_i - the measured delay, t_{io} - the constant delay, determined by electronics and geometry, v(t) - drift function, taken from [2] for first iteration. The deflexion $\Delta x_i = x^f - x_i$ was calculated during iteration, here x^f -the extrapolated value. The mean value Δx connected with t_o was minimized. The drift function was obtained from tube which not participated in treatment: $v(t_k) = x_k^f/(t_k - t_{ko})$, here x^f - the extrapolated value of coordinate, t_k -the measured delay in this tube. The calculated values v(t) were tabulated to use in following iteration. In fig.7 the plots related to drift function are drawn. The dependence of $\sigma(\Delta x)$ from high high voltage are shown in fig.8a. The better resolution was obtained for limited streamer mode σ=121$\pm$4 μm. In proportional mode the resolution is worse probably because of preamplifier time response. For smaller prototype we had fast preamplifier with 5 ns rise-time. In fig.8b the resolution obtained by described method are shown for 8 tubes with 15 cm length.

Application to GEM muon system.

The flexibility of this chamber design to various condition give a good chance to use such type of detectors in GEM muon system.

- Pressurized drift tubes.
  The mean idea to use overpressure is to improve the spatial resolution as $1/\sqrt{p}$ (if electronics work by first claster). The resolution 100 μm of single tube requiring in GEM can be obtained at pressure about 2 atm. which is allowed for mylar tubes. The mylar tubes reduce the number of radiation lengths in the middle superlayer from 8.5 % for aluminum tubes to 1 %. In fig.9 the reconstructed mass distribution of Higgs for different thickness is shown[3]. Note that energy loss in matter (for ex. due to δ-electron) can increases the hit rate in muon chamber and so the occupancy. The weight of muon system will reduce in 6 time improving the engineering construction. The alignment of mylar tubes is determined by accurate placement of signal wires in manifold plate independent of tubes. The anode wire offset relative to tube about 1 mm is admitted for normal work [4].

- The strip read-out.
  The possibility of strip read-out is the advantage of plastic tubes. Two ways exist for this purpose. First is to use carbonized mylar with low conductivity. More simple is to use electrodless gape on cathode. In fig.10 possible strip read-out is shown. The limited streamer mode is preferable as provide us large and fast signals for wires and strip read-out with spatial resolution 100 μm and 50 μm respectively. In this case L-R ambiguties will be resolved by cathode read-out of induced signals.

- Multitrack resolution.
  The track reconstruction of high momentum muon will impede by punchthrough, bremsstrahlung, etc. Still no clear simulation of μ energy loss in GEM but the problem of multitrack resolution will arise. The linear drift line in tubes can be obtained by striped cathode with field shaping. The field contour and drift line of such tube are shown on fig.11. The influence of magnetic field is shown in fig.11b. The multitrack resolution about 5 mm is estimated from simulation.

Conclusion.

The prototype of ligt muon detector 3 m long consisting of 64 tubes can be made for GEM tracking. The configuration is shown in fig.12. The estimated cost of prototype are given in table 1.

For the future we have planned several activities. We shell optimize the electronics. The resolution in magnetic field and the strip read-out will be studied.

References.

1. L.Golovanov et al. Preprint JINR, 92 (be published).
2. F.Sauli, A.Peisert. Preprint CERN 84-08.
3. GEM letter of intent. SSCL-SR-1184, 91.
4. S.H.Oh rt al. Proc. symposiom on detector research and development for SSC. 213, 1990.

Figure captions.

1. Experimental set-up.
2. Schematics of the read-out electronics.
3. Efficieny curves on beam.
4. Charge spectra in proportional mode.
a) Ar-Isob, b) Ar-Co2
5. Streamer mode charge spectra for Ar-Isob gas mixture.
a) HV=2.8 kV, b) HV=2.9 kV
6. Charge fluctuation vs HV.
7. Drift function.
a) Ar-Isob, b) Ar-Co2
8. Spatial resolution vs HV.
a) 1 m prototype, preamp. 10 ns rise-time,
b) 15 cm prototype, preamp. 6 ns rise-time.
9. Higgs mass distribution for different number of radiation lenght.
10. Schematics of strip read-out.
11. The field shaping drift tube.
a) B=0, b) B=0.8 tesla
12. The prototype layout.

beam
S1
S2
64 tubes ø 10mm
π, 5 Gev/c
0000.....0000
1
64

Fig. 1

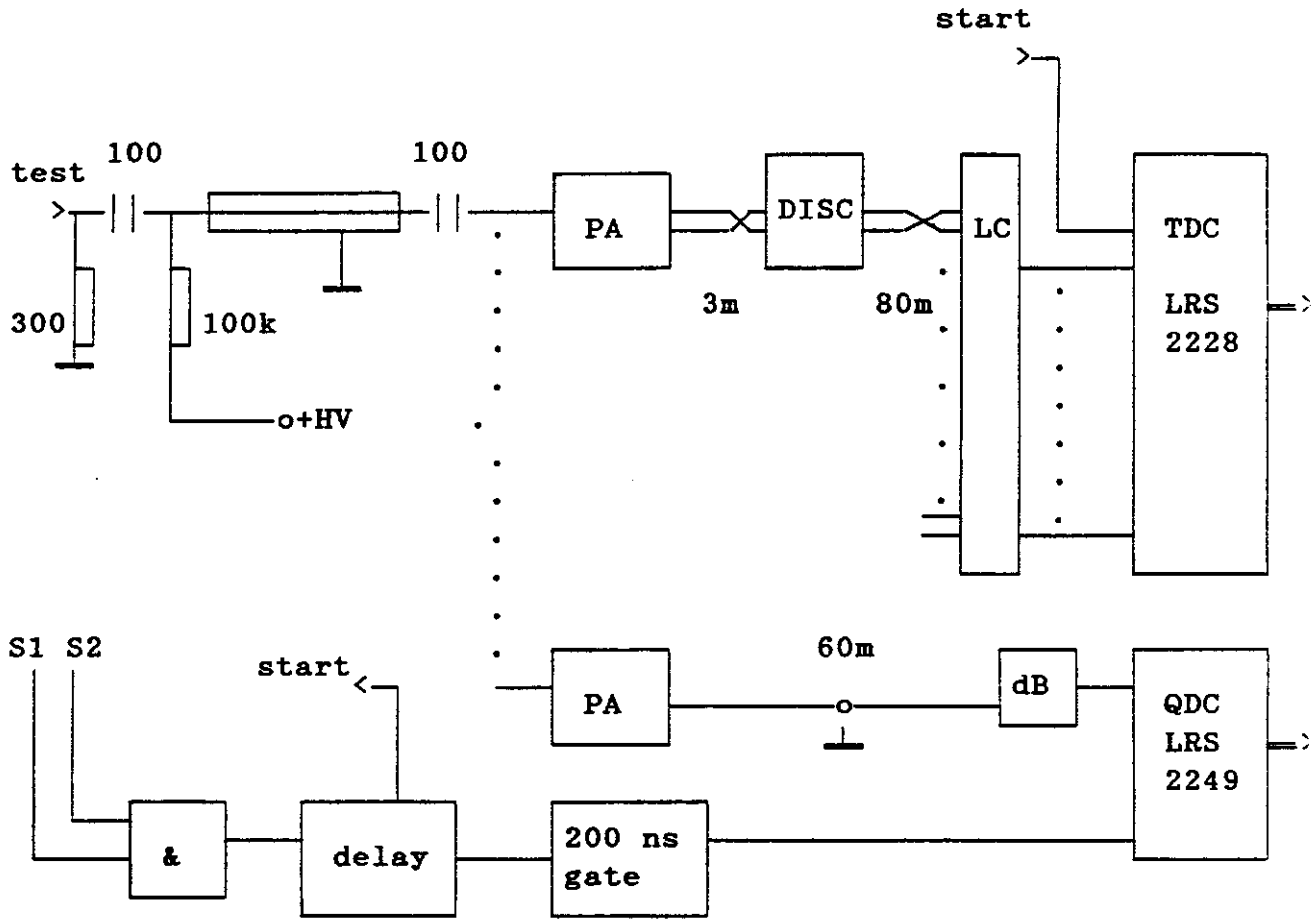

start
test
100
100
PA
DISC
LC
TDC
LRS
2228
300
100k
o+HV
3m
80m
S1 S2
start
60m
PA
dB
QDC
LRS
2249
&
delay
200 ns
gate

Fig. 2

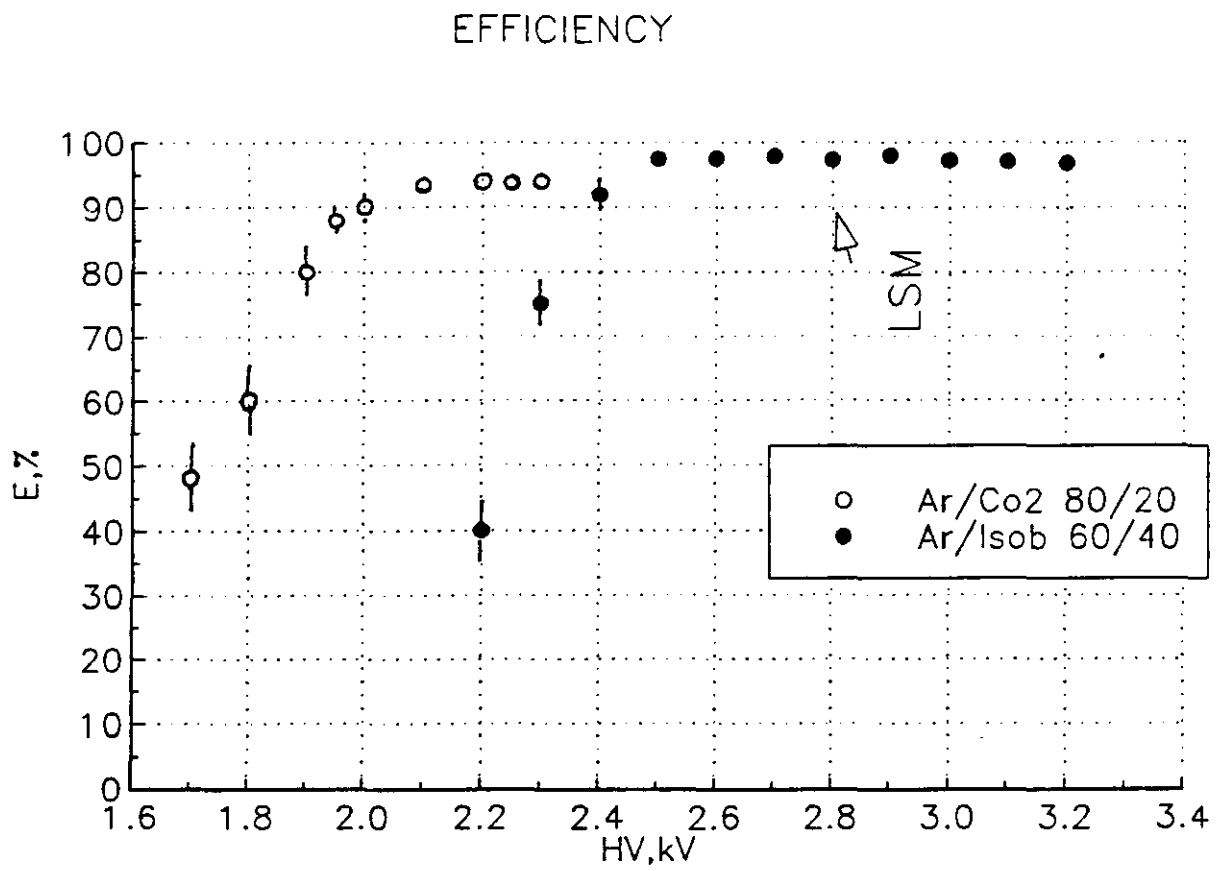

EFFICIENCY
E,%
HV,kV
LSM
Ar/Co2 80/20
Ar/Isob 60/40
0
10
20
30
40
50
60
70
80
90
100
1.6
1.8
2.0
2.2
2.4
2.6
2.8
3.0
3.2
3.4

Fig.3

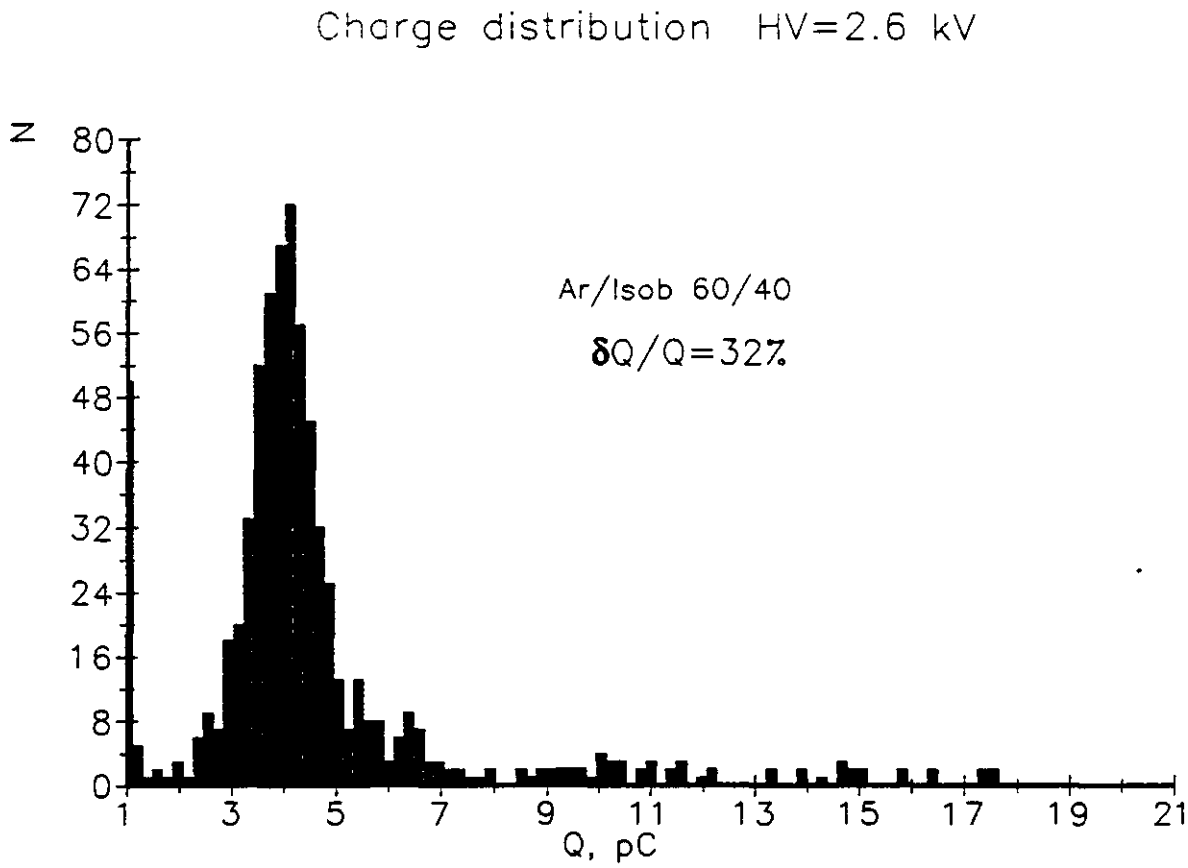

Charge distribution HV=2.6 kV
N
80
72
64
56
48
40
32
24
16
8
0
Ar/Isob 60/40
δQ/Q=32%
1
3
5
7
9
11
13
15
17
19
21
Q, pC

Fig.4a

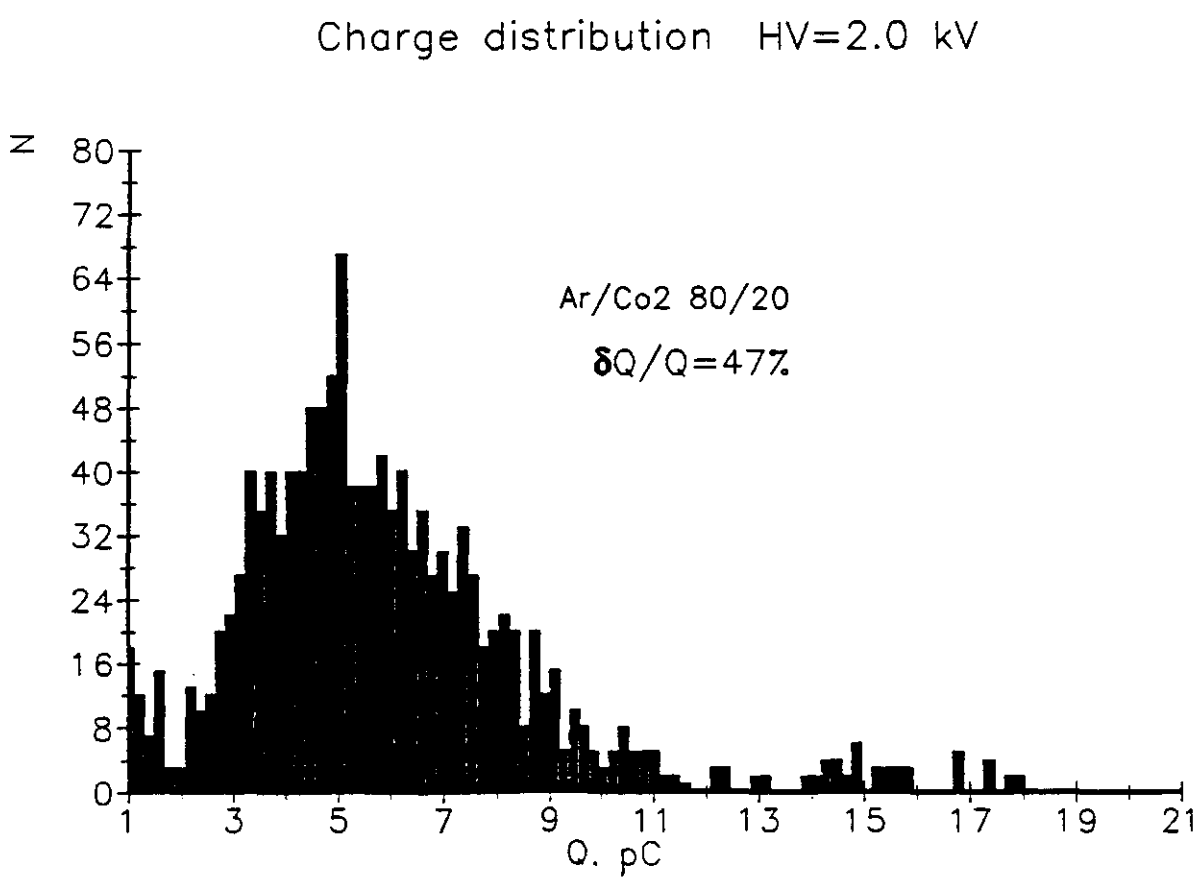

Charge distribution HV=2.0 kV
N
80
72
64
56
48
40
32
24
16
8
0
Ar/Co2 80/20
δQ/Q=47%
1
3
5
7
9
11
13
15
17
19
21
Q, pC

Fig.4b

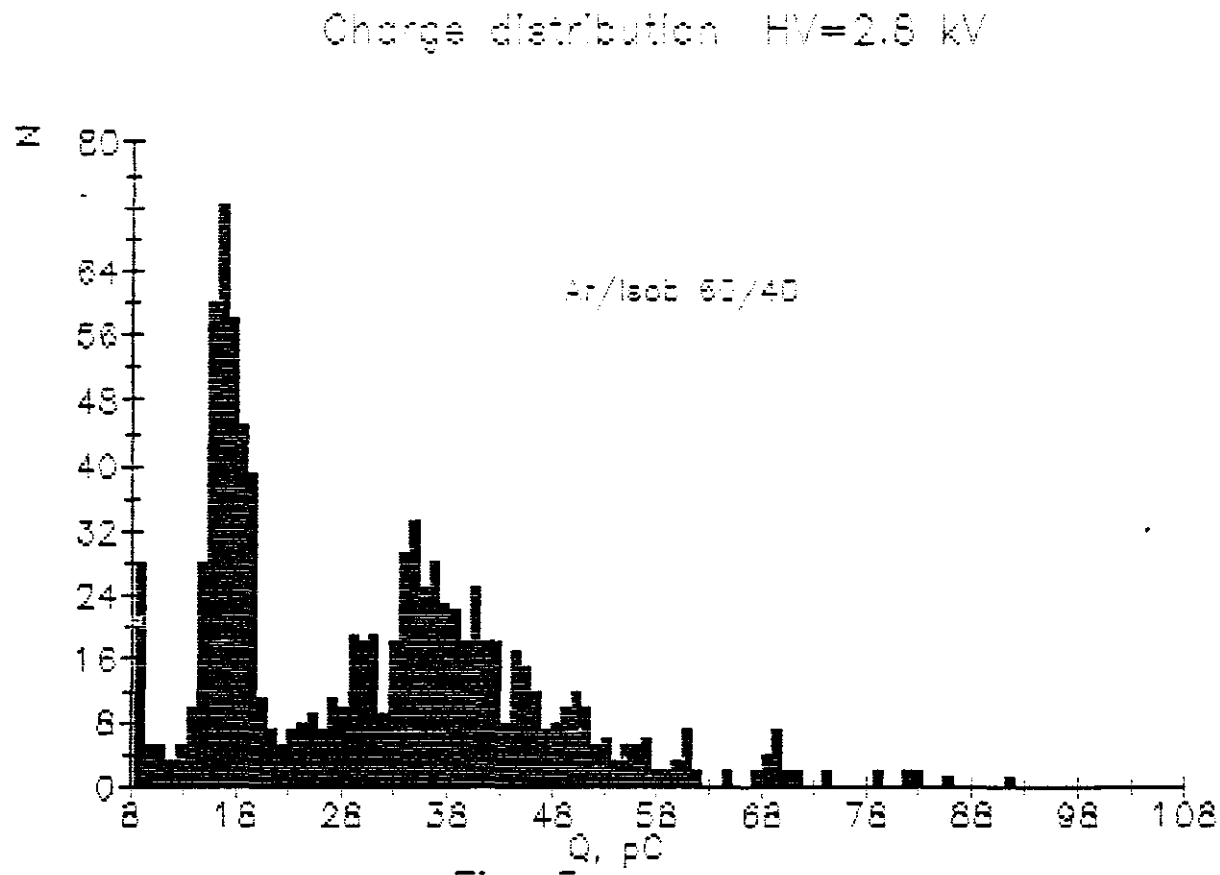

Charge distribution HV=2.8 kV
N
80
64
56
48
40
32
24
16
8
0
Ar/Isob 60/40
8
16
28
38
48
58
68
78
88
98
108
Q, pC

Fig. 5a

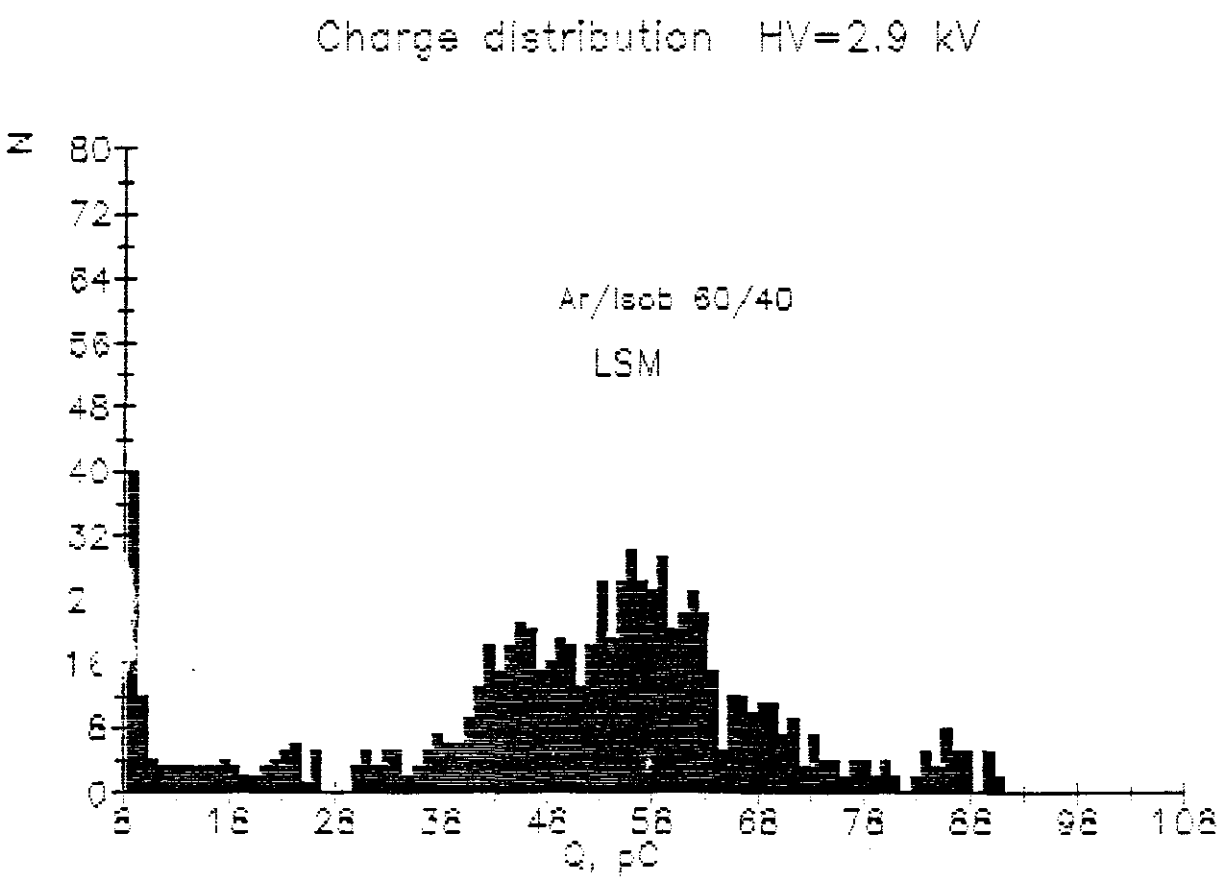

Charge distribution HV=2.9 kV
N
80
72
64
56
48
40
32
2
16
8
0
Ar/Isob 60/40
LSM
8
16
28
38
48
58
68
78
88
98
108
Q, pC

Fig 5b

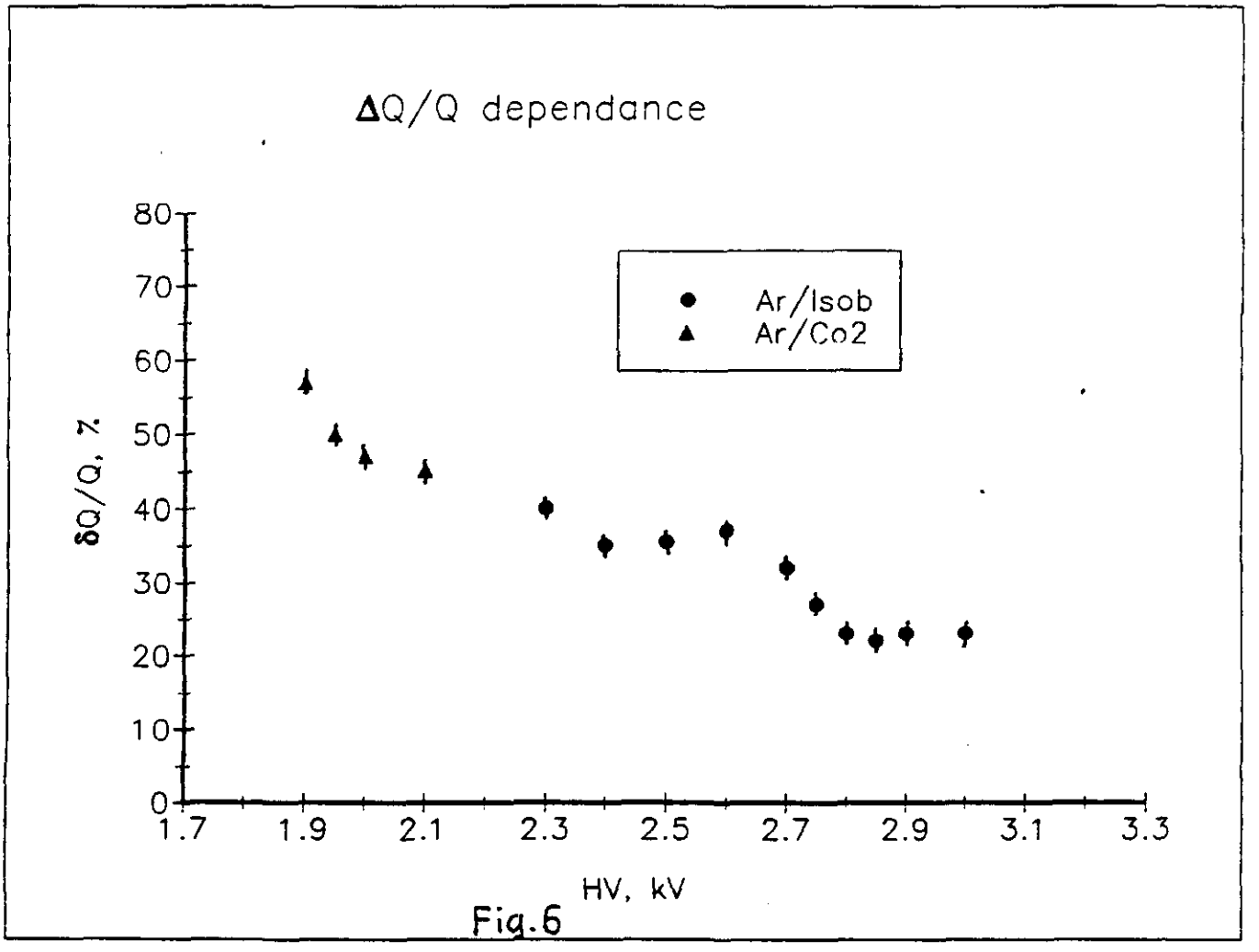

ΔQ/Q dependance
80
70
60
50
40
30
20
10
0
δQ/Q, %
Ar/Isob
Ar/Co2
1.7
1.9
2.1
2.3
2.5
2.7
2.9
3.1
3.3
HV, kV

Fig.6

Drift function

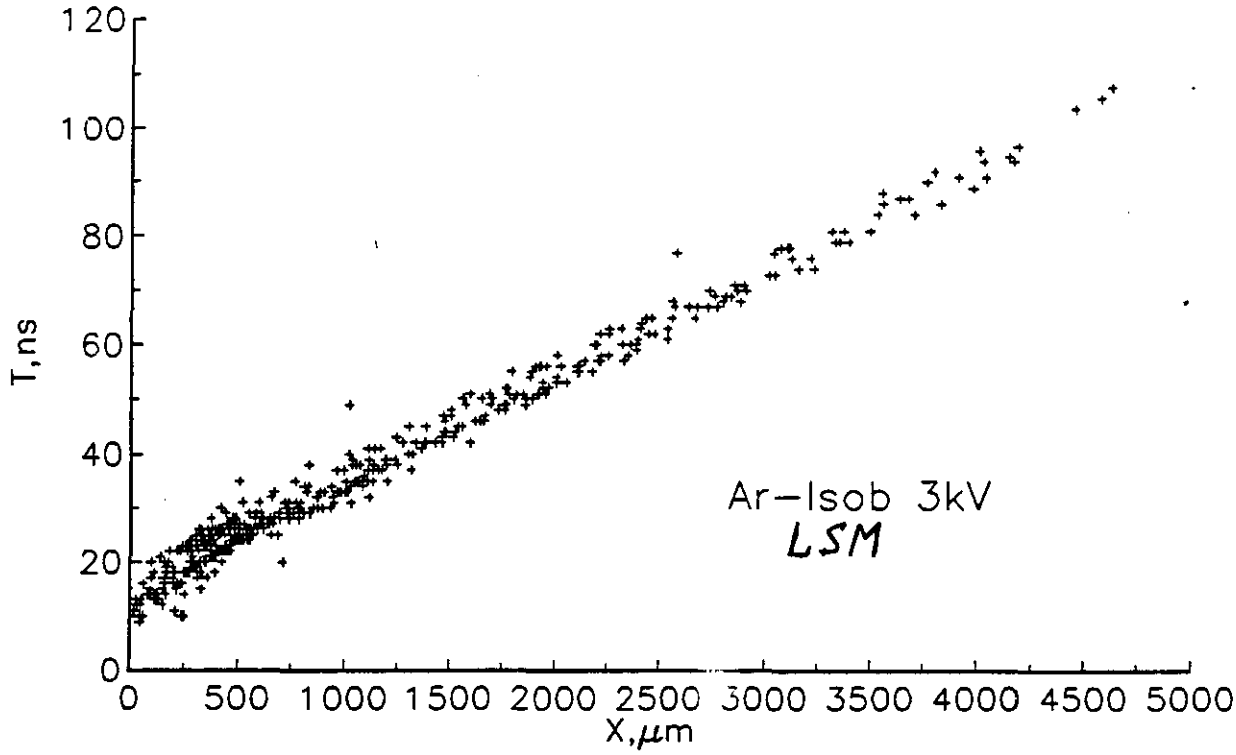


Fig.7a

Drift function

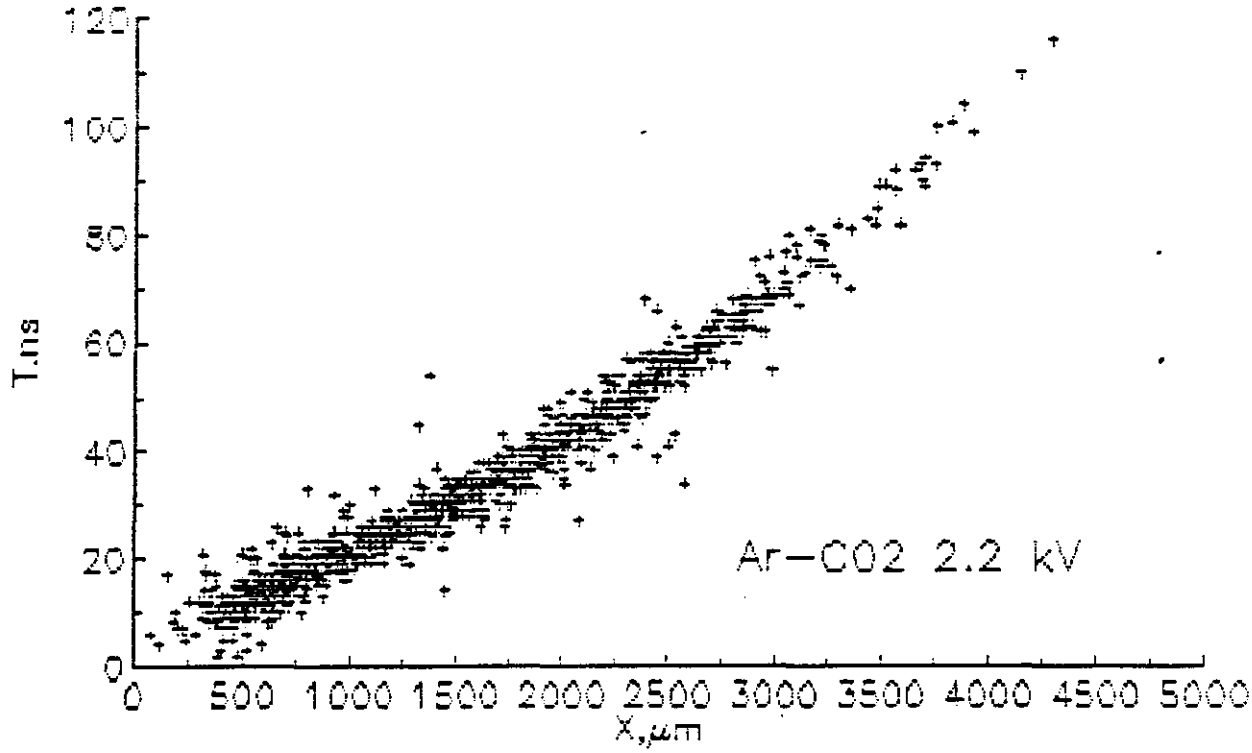


Fig.7b

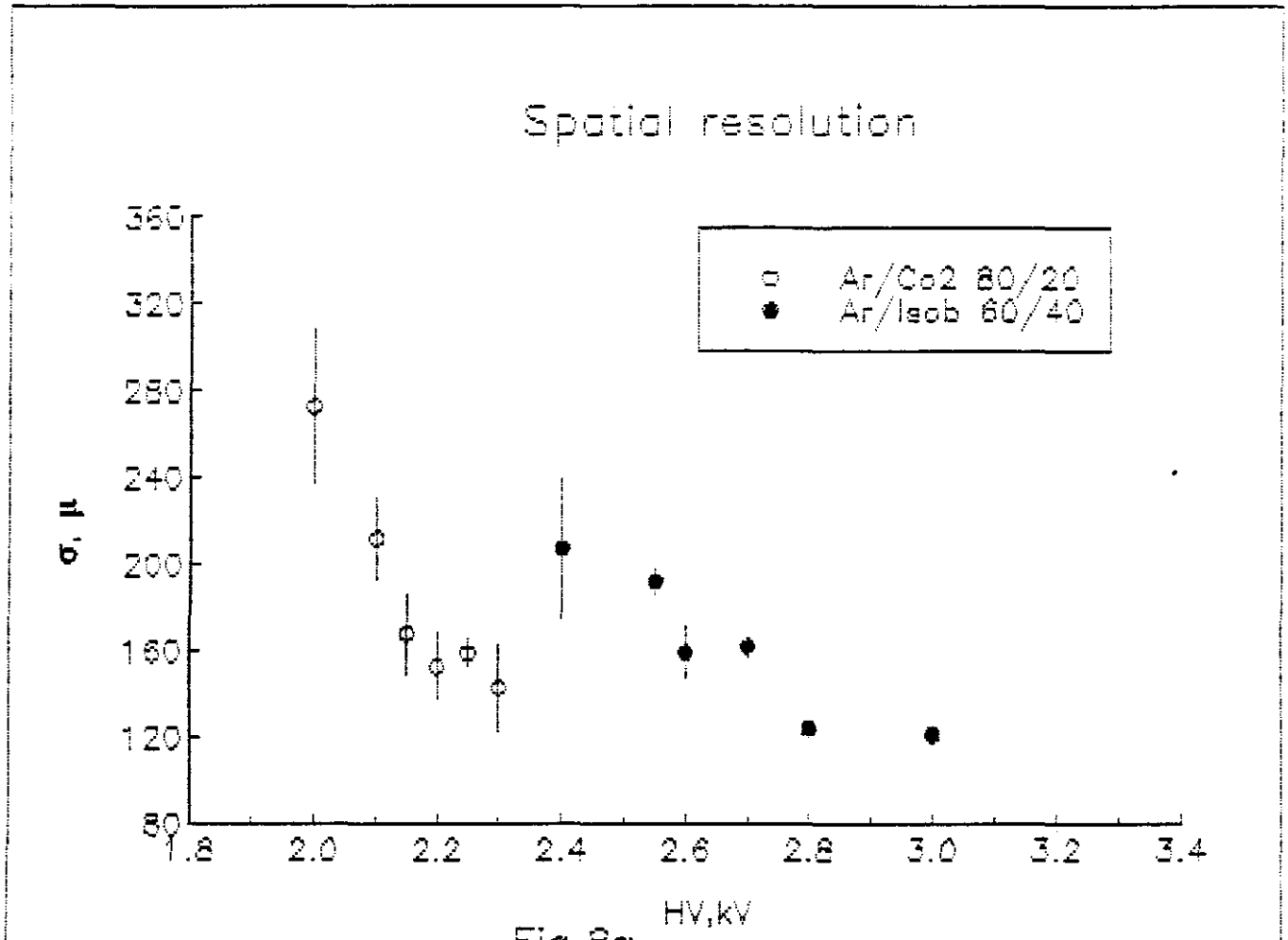

Spatial resolution
Ar/Co2 80/20
Ar/Isob 60/40
σ, μ
360
320
280
240
200
160
120
80
1.8
2.0
2.2
2.4
2.6
2.8
3.0
3.2
3.4
HV,kV

Fig.8a

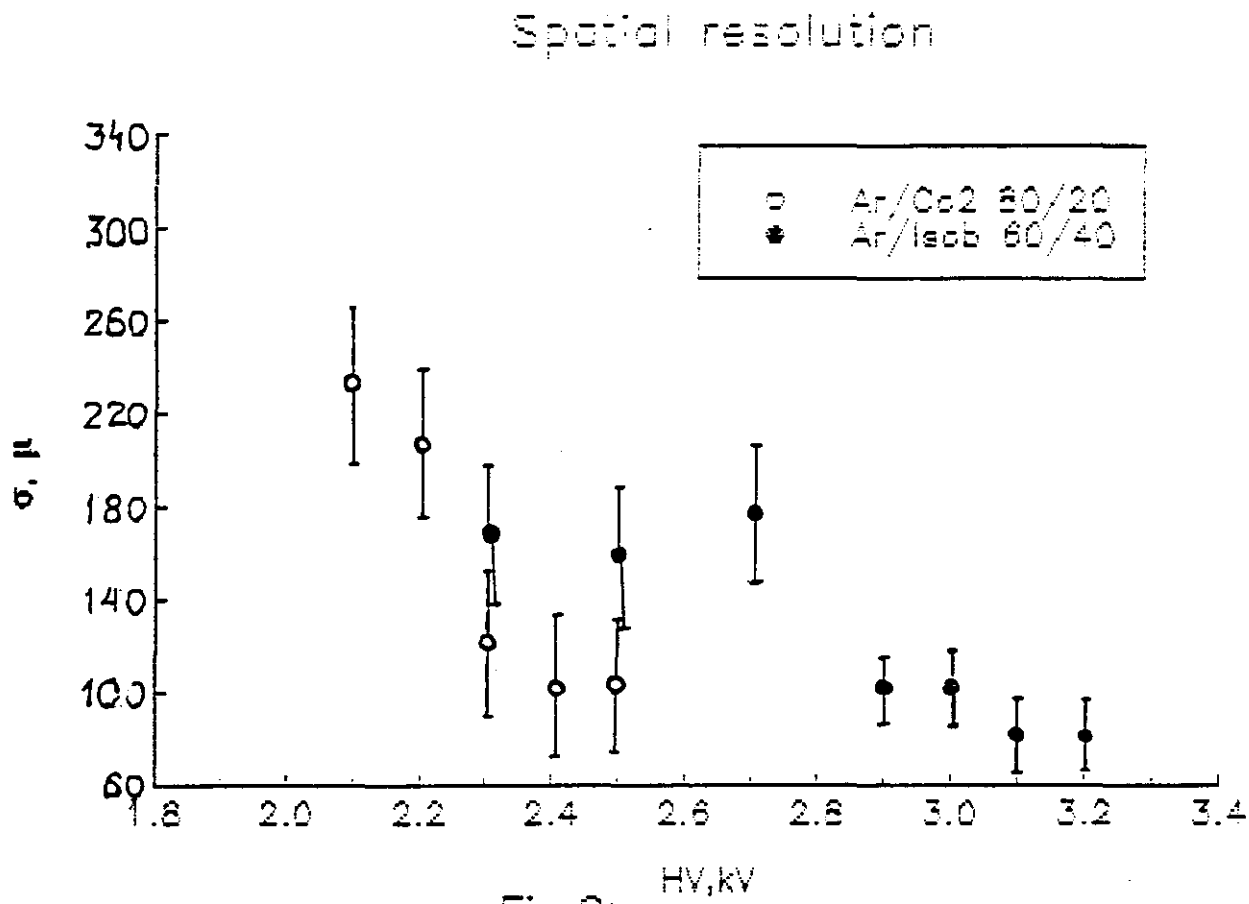

Spatial resolution
Ar/Co2 80/20
Ar/Isob 60/40
σ, μ
340
300
260
220
180
140
100
60
1.8
2.0
2.2
2.4
2.6
2.8
3.0
3.2
3.4
HV,kV

Fig.8b

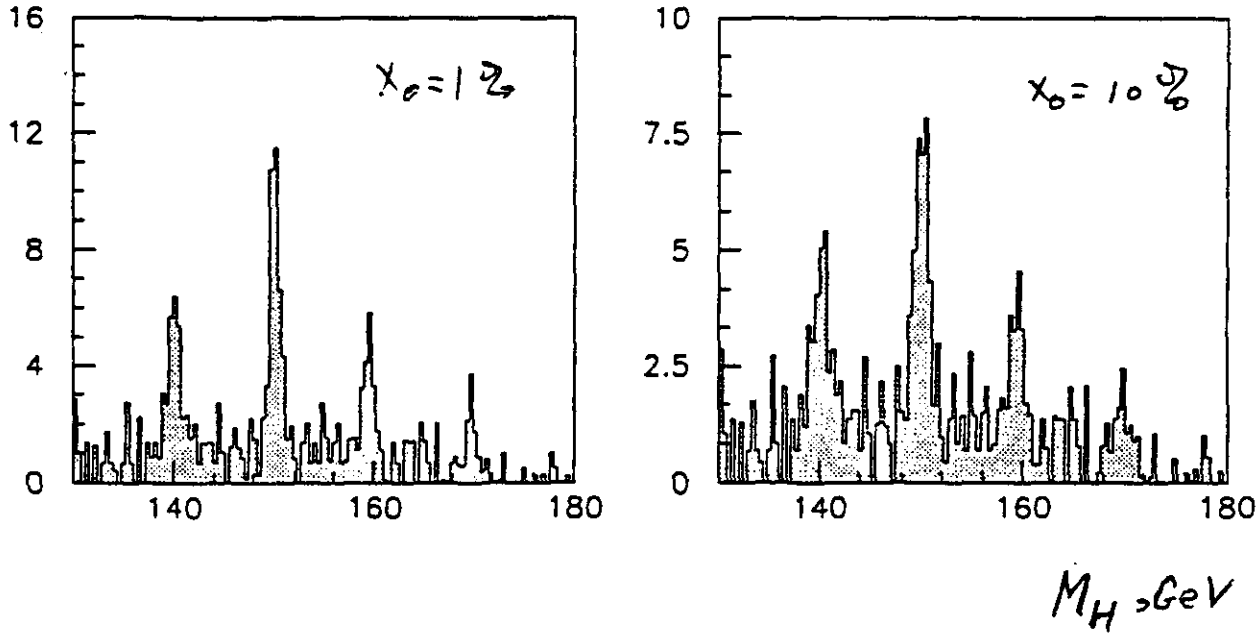

16
12
8
4
0
140
160
180
$X_0 = 1\%$
10
7.5
5
2.5
0
140
160
180
$X_0 = 10\%$
M_H, GeV

Fig. 9

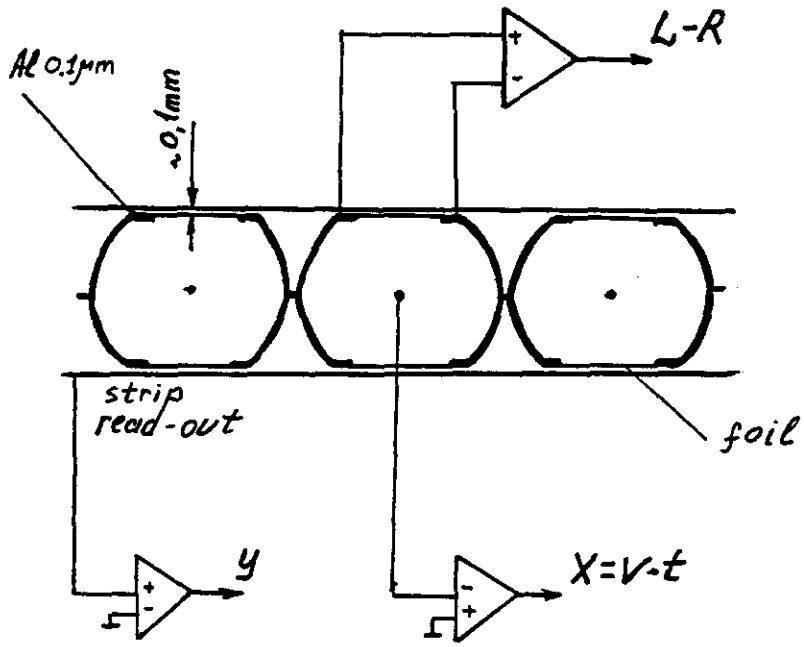
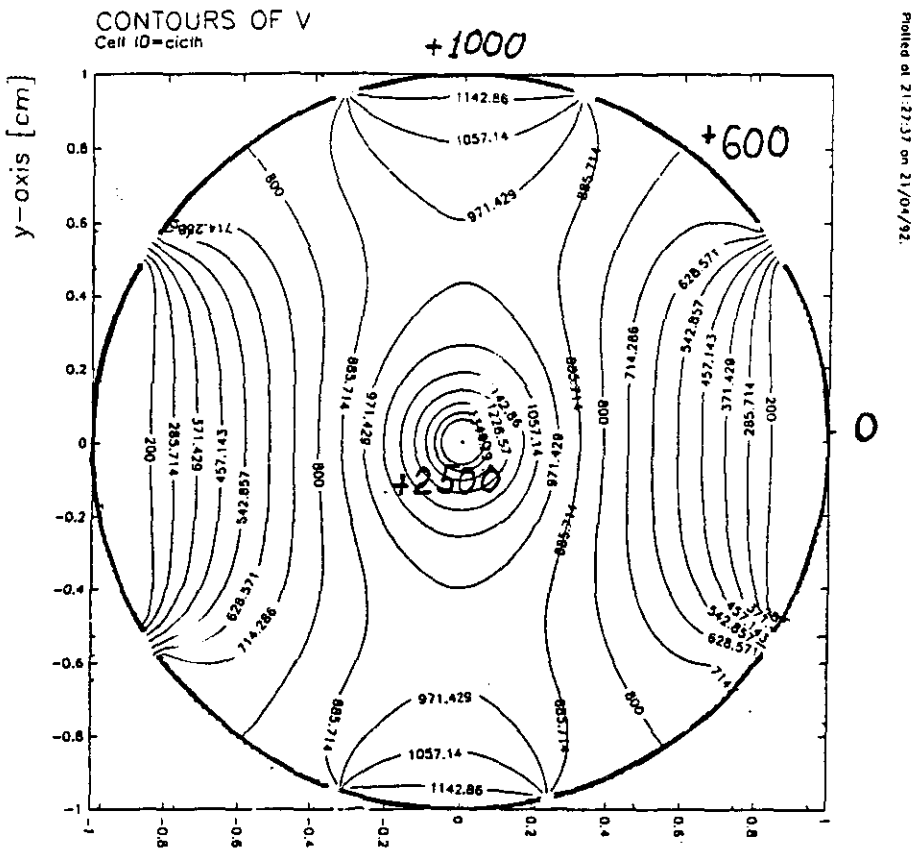

Al 0.1μm
~0,1mm
L-R
strip
read-out
foil
y
X=V·t

Fig. 10


CONTOURS OF V
Cell ID=cicth
+1000
+600
+2500
0
y-axis [cm]
Plotted at 21:27:37 on 21/04/92.

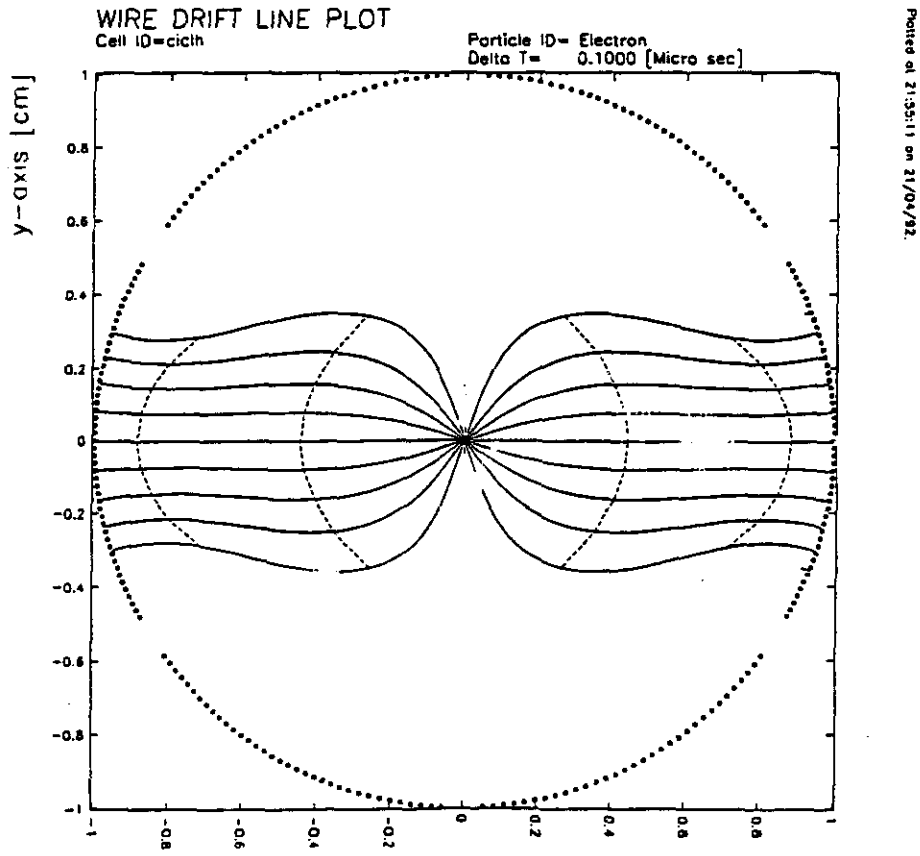
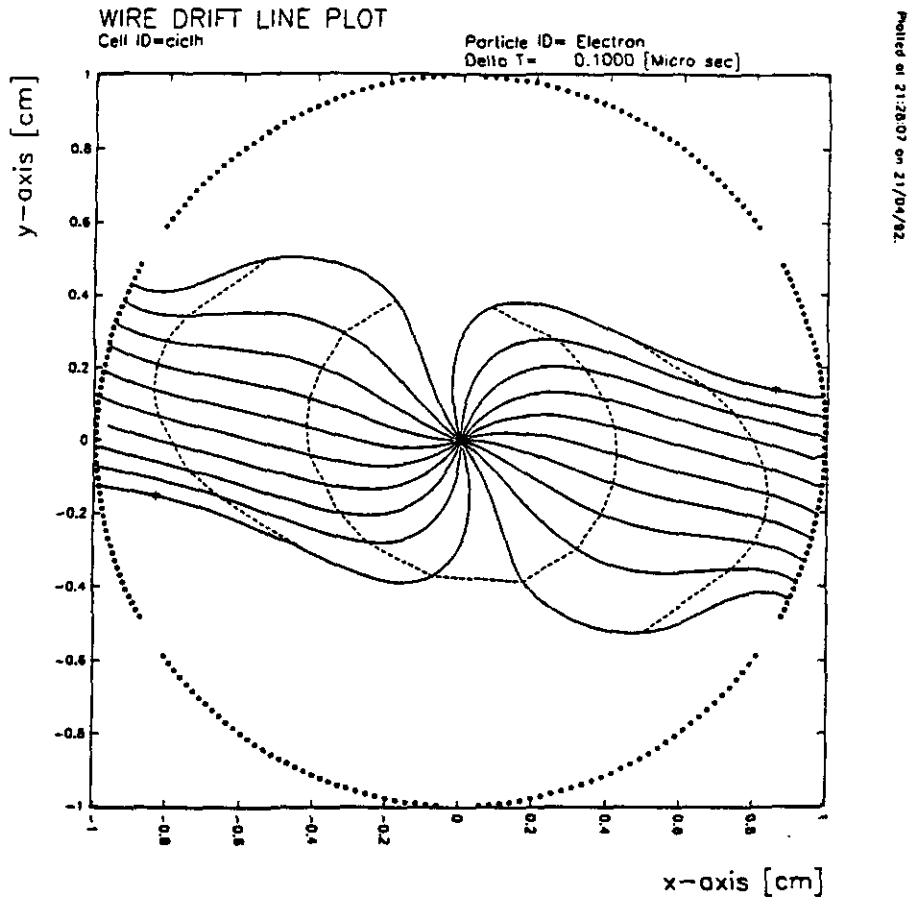

WIRE DRIFT LINE PLOT
Cell ID=cicth
Particle ID= Electron
Delta T= 0.1000 [Micro sec]
y-axis [cm]
Plotted at 21:35:11 on 21/04/92.

Fig. 11a


WIRE DRIFT LINE PLOT
Cell ID=cicth
Particle ID= Electron
Delta T= 0.1000 [Micro sec]
y-axis [cm]
x-axis [cm]
Plotted at 21:28:07 on 21/04/92.

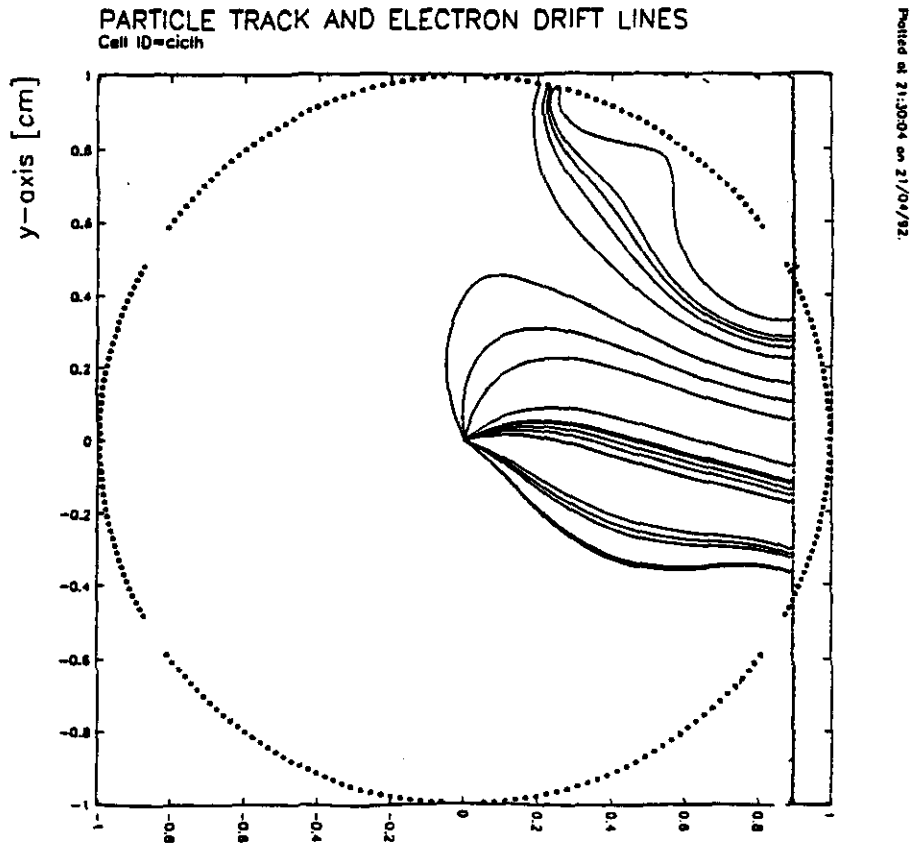

PARTICLE TRACK AND ELECTRON DRIFT LINES
Cell ID=cicth
y-axis [cm]
Plotted at 21:30:04 on 21/04/92.

Fig. 11b