GEM TN-92-72
PDT-BU-92-1

Drift Gas Studies for GEM Muon System

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February 1992

Abstract:

Using a specially designed test drift chamber, we present preliminary studies using several gas mixtures which are candidates for the GEM PDT muon system. Drift velocities and Lorentz angles were measured at various magnetic and electric fields intensities.

GEM MEMO
PDT-BU-92-1

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1. Introduction

The Pressurized Drift Tubes system (PDT) is one of the main candidates for the GEM muon system. Our Boston University group has large experience in using both stainless steel drift tubes and thin wall drift tubes. One of us (SA) was a member of the HRS collaboration, for which 3.6m stainless steel tubes were build. One octant of those tubes (about 100 tubes) is presently at Boston University, where studies on long term wire tension behaviour and resolution measurements at various pressures are in progress. Various sizes and types of drift tubes were used for our balloon borne experiments such as EXAM (3.7m stainless steel drift tubes), PBAR, and SMILI (thin wall drift tubes), tubes build by our group at Boston University. Those drift tubes performed very well and suffered accelerations up to 10g without damage.

Our previous gas studies indicated resolutions as low as 35 microns with slow gases such as DME (which also has small Lorentz angles) and about 80 microns with Argon Ethane.

The drift gas for a muon system in the SSC environment is required to have the following features:

(1) High drift velocity to reduce the occupancy level.

(2) Extremely low ageing to improve the detector lift time.

(3) Fast rise time and short pulses.

(4) Good intrinsic gas resolution.

(5) High gas gain to allow operating the chamber in relatively low voltages.

We have built two special drift chambers for gas studies. One chamber is located at the MIT cyclotron magnet (magnetic field from 0 to 10kG); the other one is located at Indiana University. The results can be cross checked by two independent measurements.

We report here our gas study apparatus, system calibration, and some preliminary measurement results.

2. Apparatus for Drift Velocity and Lorentz Angle Measurements

Fig. 1 shows the schematic of the experimental setup. The drift chamber is located in the center of a dipole magnet, and within the fiducial volume the magnet field is constant to $< 1\%$.

Drift velocity is measured by five sense wires, which are transverse to the B-field, while the drift angle is measured by 31 pads, which are parallel to the magnetic field lines. A UV laser is located about 2 meters from the test chamber. The laser beam is focused to about 200 microns beam diameter. The moveable mirror is used to inject the UV beam into the chamber perpendicular to the sense wires to produce the ionization electrons.

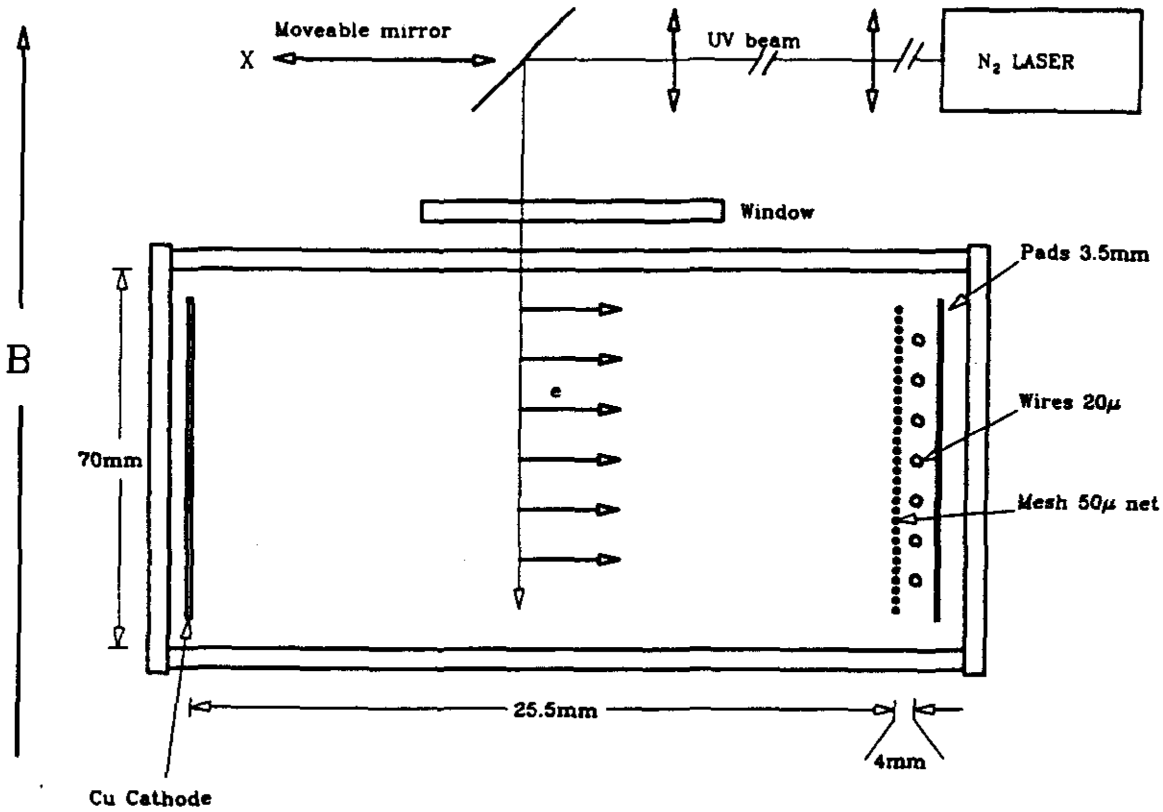


Figure 1 *Schematic of the experimental set-up*

Fig. 2 gives the drift chamber configuration, which is based on an design by MIT Prof. U. Becker. The chamber has a *drift* region with uniform drift fields provided by a solid copper cathode and a *detection* region with 5 sense wires, 11 cm long, biased at 1.5-3.0 kV for the necessary gas amplification. The 31 pads transverse to the wires collects the induced charge for z-coordinate measurements.

In order to cancel the *'detection region'* E-field uncertainty, for given E-field and B-field, we perform three measurements by moving the laser beam in three locations as shown in the figure 2.

The sense wires are AC-coupled to the input of an amplifier/comparator (LeCroy 2735D) with gain 25 mV/μA. The wire signals from 2735D are then directed to the inputs of a LeCroy 2228 TDC (50 ps/channel) for the drift time measurements. The

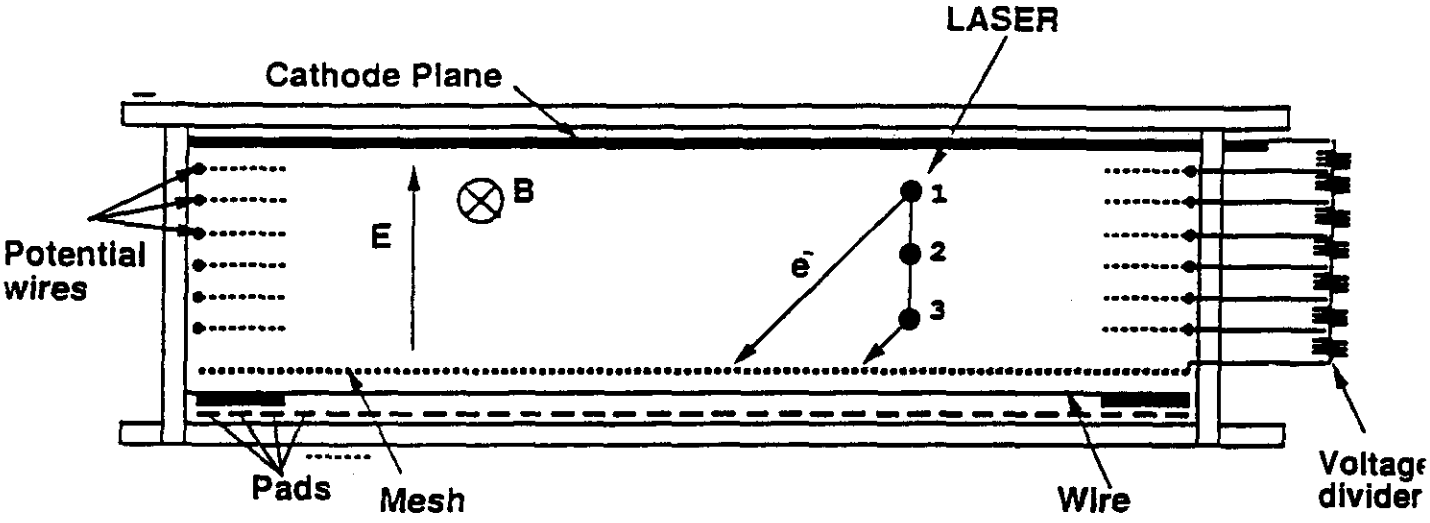


Figure 2 *Schematic of the test chamber configuration.*

charge induced in the pads are amplified by a LeCroy TRA1000 amplifier and then analyzed by an charge sensitive ADC (LeCroy 2259B). From the charge distribution in different pads, we can determine the z-coordinate with a precision better than 200 microns. Fig. 3 show the pulse shape from the wire and from the pads.

3. System Calibration

System calibration includes:

(1) Laser beam optical focus.

(2) Laser beam direction relative to the sense wires and pads.

(3) E-field high voltage (from 0 - 50kV).

(4) TDC and ADC linearity.

(5) Amplifier gain.

(6) Gas mixture precision.

We already achieved the following system precision:

(1) Laser beam size: ~ 200 microns.

(2) Laser beam direction alignment perpendicular to pads within 0.5 degree.

(3) E-field high voltage accurate to 3%.

(4) Gas mixture is reproducible ~ 1%.

P10 gas is one of the most sensitive gases to test the above system calibration parameters. Figure 4 shows the drift velocity curves for this gas. The two curves in the figure are from two different measurements with gas mixture done at different times. By comparing our results with previous measurements (CERN report 84-08), we can conclude that the drift velocity measurement errors are of the order of 1% .

4. Preliminary Gas Measurements

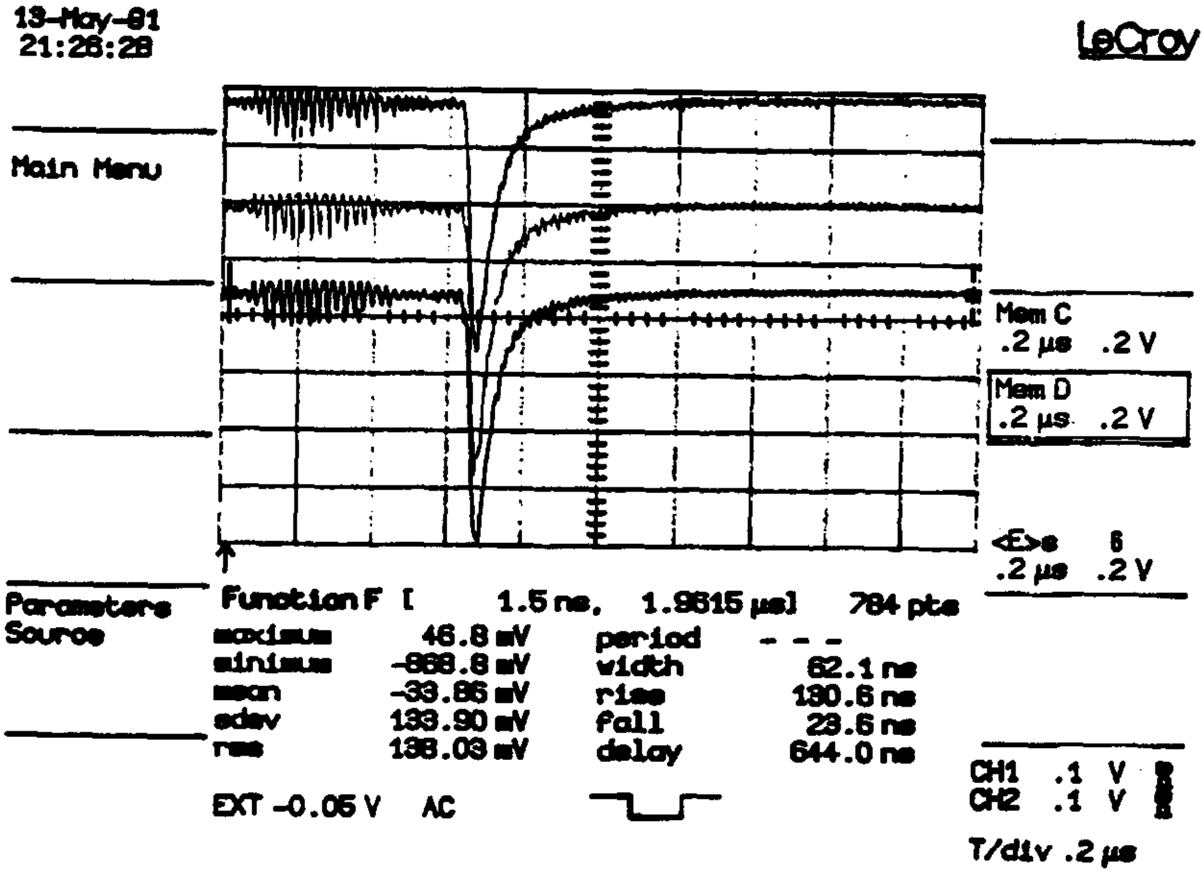
We studied CF_4/*isobutane* (80/20) gas, a possible candidate for the PDT gas detector because its high drift velocity and extremely low ageing property. However we found that CF_4 mixtures have strong negative electron attachment behavior: the pulse height decreases as the drift distance increases. We also find that such behavior is different for different gas bottles (due to different type and/or types of impurities). Figure 5 show our measurements from two different CF_4 gas bottles. With gas bottle 1 we could operate the chamber at much lower E-field. J. Va'vra (at SLAC), found the same phenomenon, but by using a NANOCHEM filter which removes halogen and other impurities, it is possible to eliminate such problems. Presently, in collaboration with Scott Whitaker and Jim Shank, we purchased such a filter, and together we are continuing to study different gases for the GEM muon system. This filter improves the electron drift life time in CF_4 based gas mixtures.

We also studied a very safe gas : $Ar/CO_2/CH_4$ (90/9/1) mixture. The drift velocities and Lorentz angle measurements are show in figure 6a and 6b.

Fig. 7 and 8 shows another fast gas (CF_4 based gas mixture) properties (drift velocity and Lorentz angle) for two types of mixtures. Those mixtures are encouraging in our way to find a safe, fast gas, and with a small B-field sensitivity.

5. Summary

We have built and set up the gas study system, and we can calibrate the system for drift velocity measurement with very small systematic error. We have started drift gas studies and obtained preliminary test results. But we are really only at the starting stage for systematic gas selection studies. We plan to continue to study fast gases for the muon system. These studies will provide useful information for the gas mixture selection criteria for any gas based detector such as PDTs, RPCs or any other drift tubes for muon or tracking systems.



```
Function F [      1.5 ns,   1.9615 µs]     784 pts
maximum        46.8 mV     period      - - -
minimum      -868.8 mV     width        62.1 ns
mean         -33.86 mV     rise        130.6 ns
sdev         133.90 mV     fall         23.6 ns
rms          138.03 mV     delay       644.0 ns

EXT -0.05 V    AC
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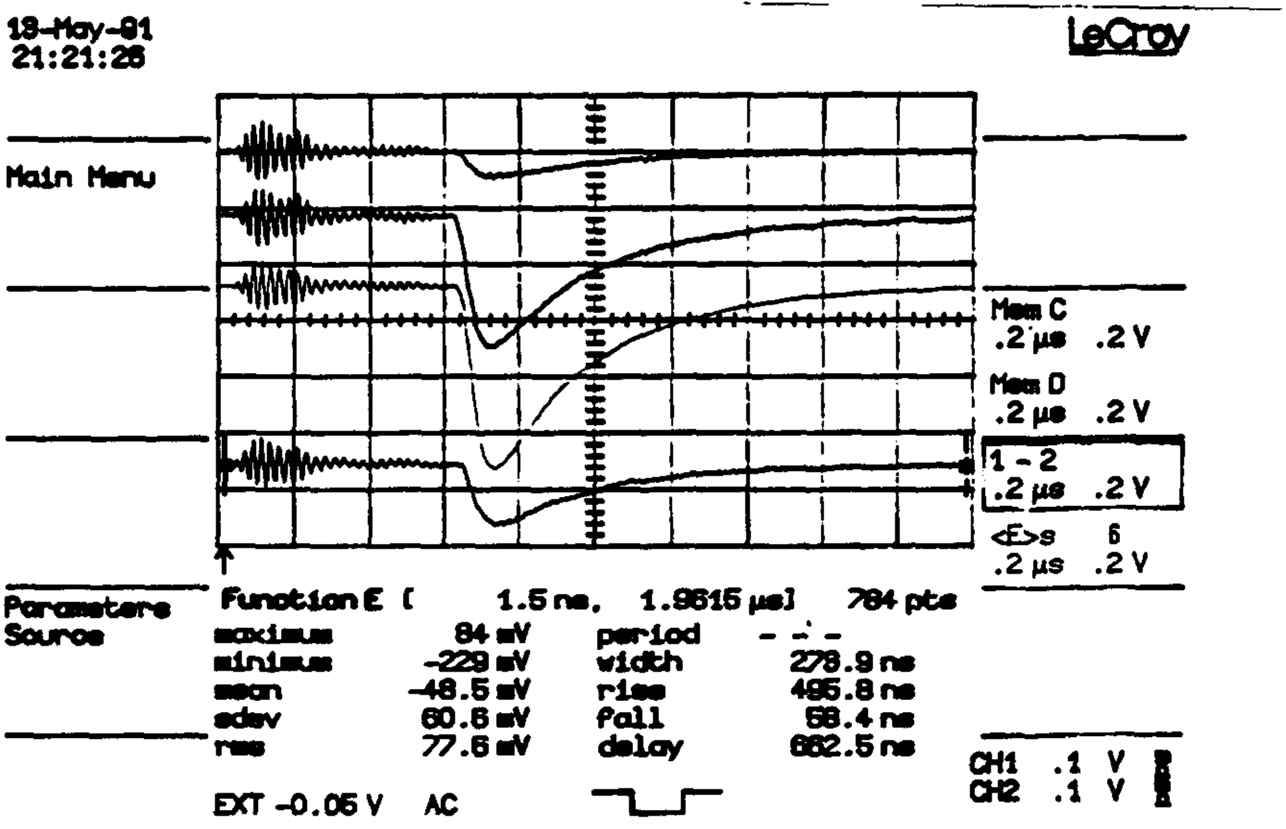
(a)



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Function E [      1.5 ns,   1.9615 µs]     784 pts
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minimum        -229 mV     width       278.9 ns
mean          -48.5 mV     rise        495.8 ns
sdev           60.6 mV     fall         58.4 ns
rms            77.6 mV     delay       662.5 ns

EXT -0.05 V    AC
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(b)

Figure 3 *a) wire 1,2,3 signals. b) pads 10,11,12,13 signals.*

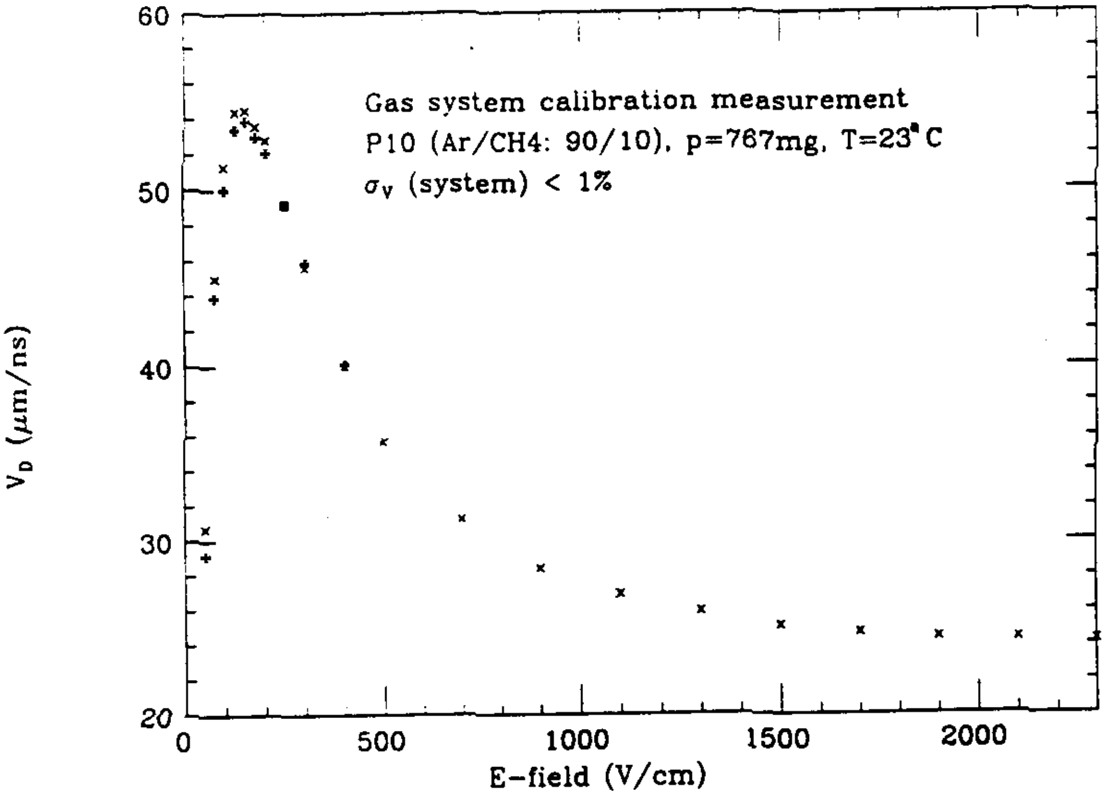


Figure 4 *P10 gas calibration: drift velocity vs. E-field.*

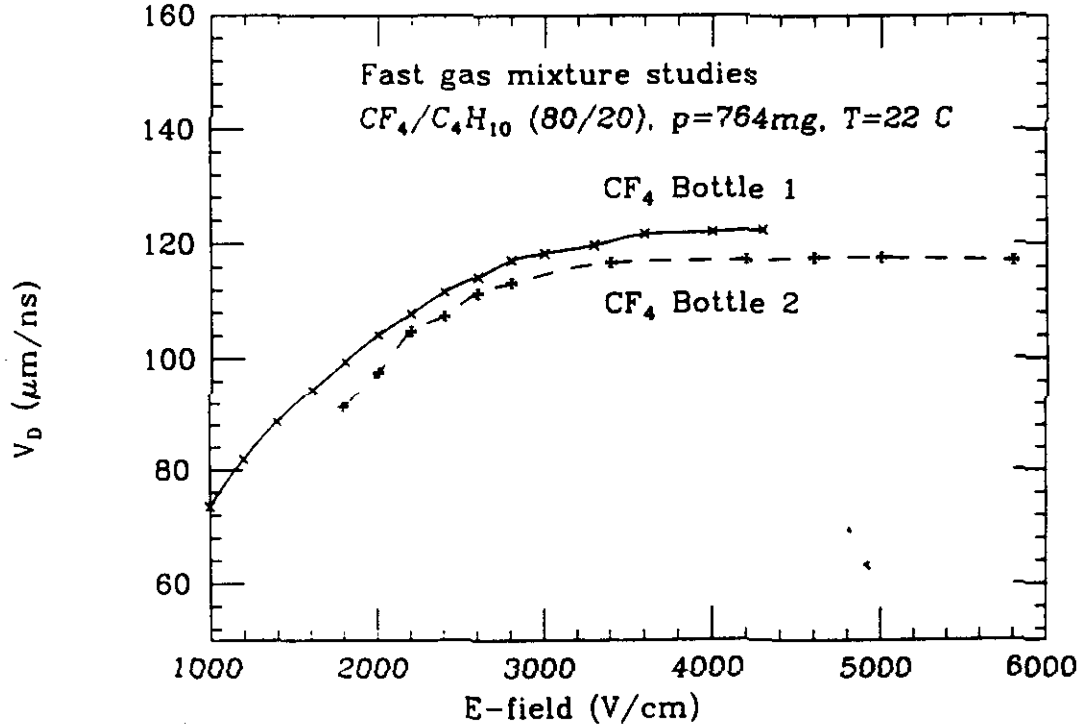


Figure 5 *CF_4 – isobutan (80-20) mixture drift velocity maesurements: solid line and dash line were measured using different CF_4 gas bottles.*

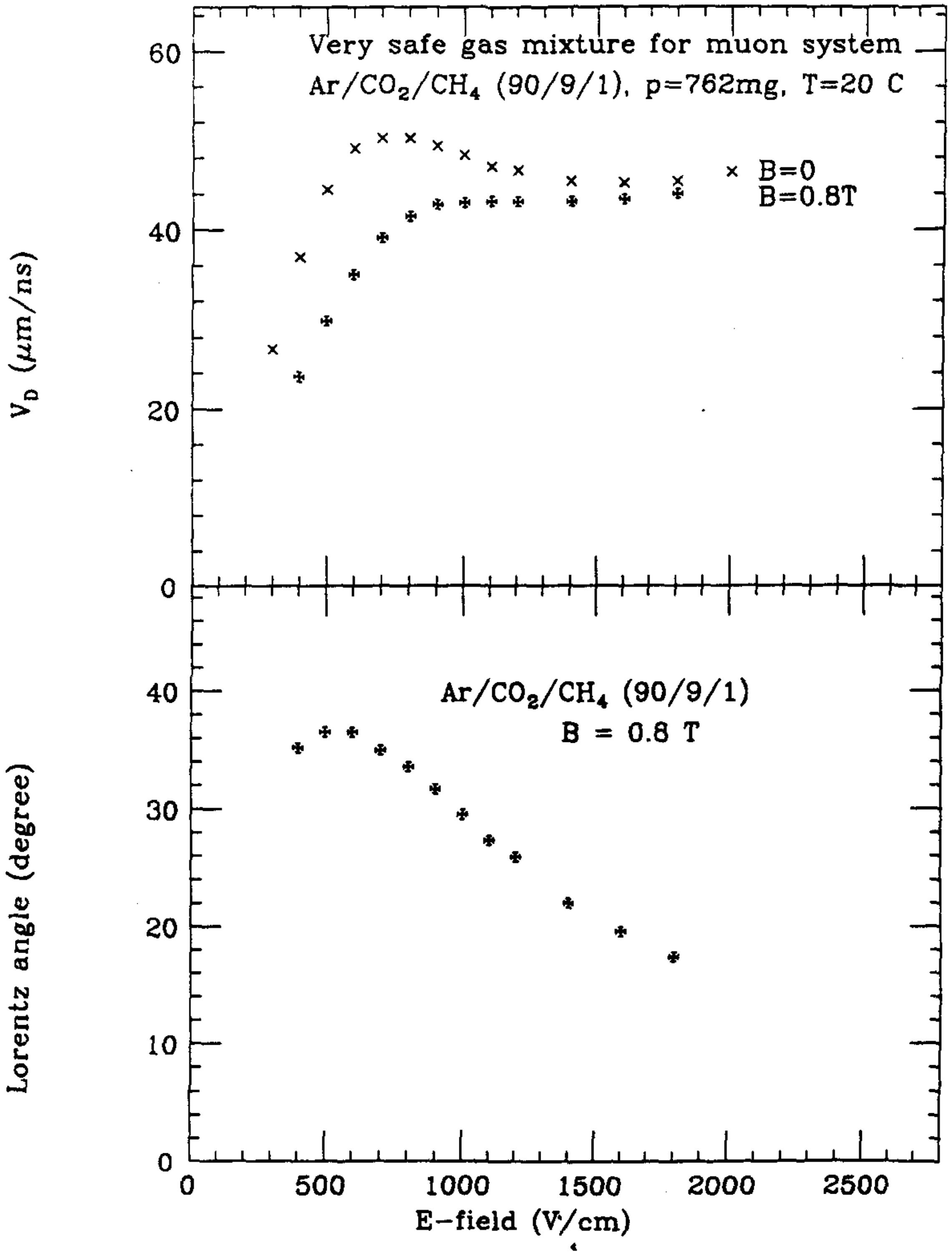
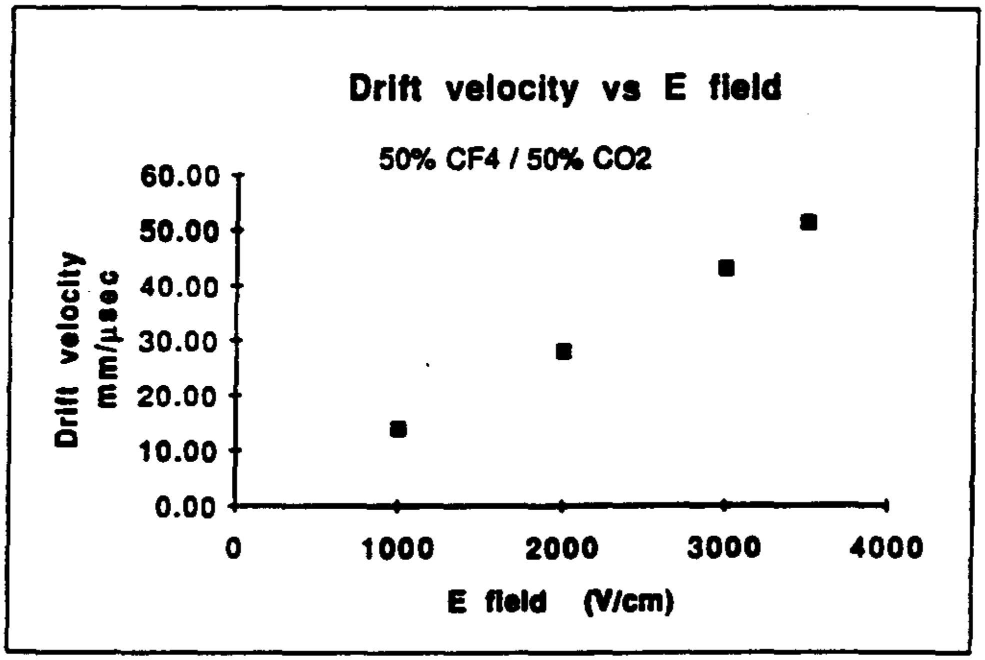


Figure 6 *Safe gas drift velocity and Lorentz angle.*

50% CF4 / 50% CO2

E field V/cm	B field Telsa	Drift vel mm/µsec	Theta L degrees
1000	0.8	13.98	5.92
2000	0.8	28.00	6.06
3000	0.8	43.13	6.26
3500	0.8	51.36	6.42



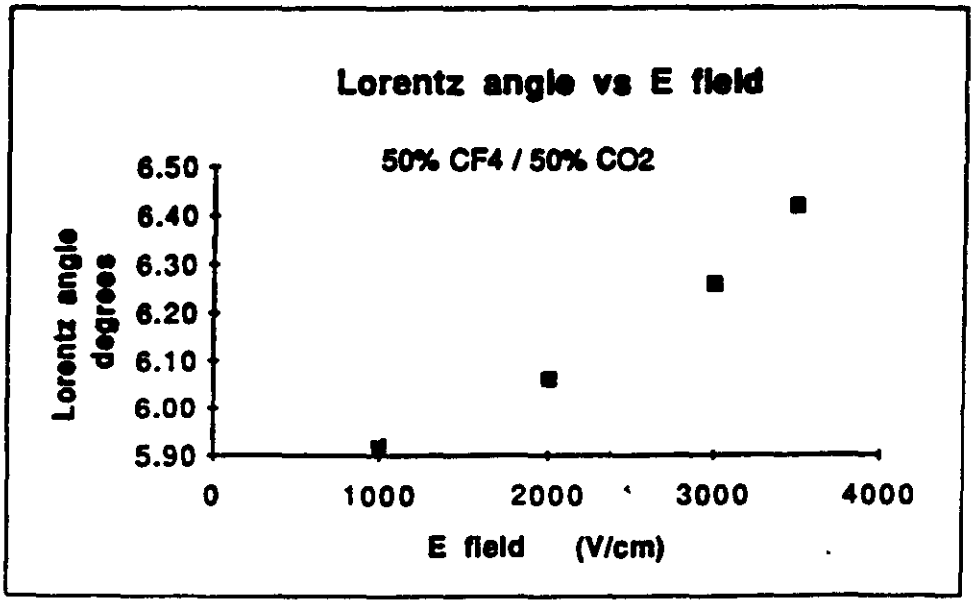
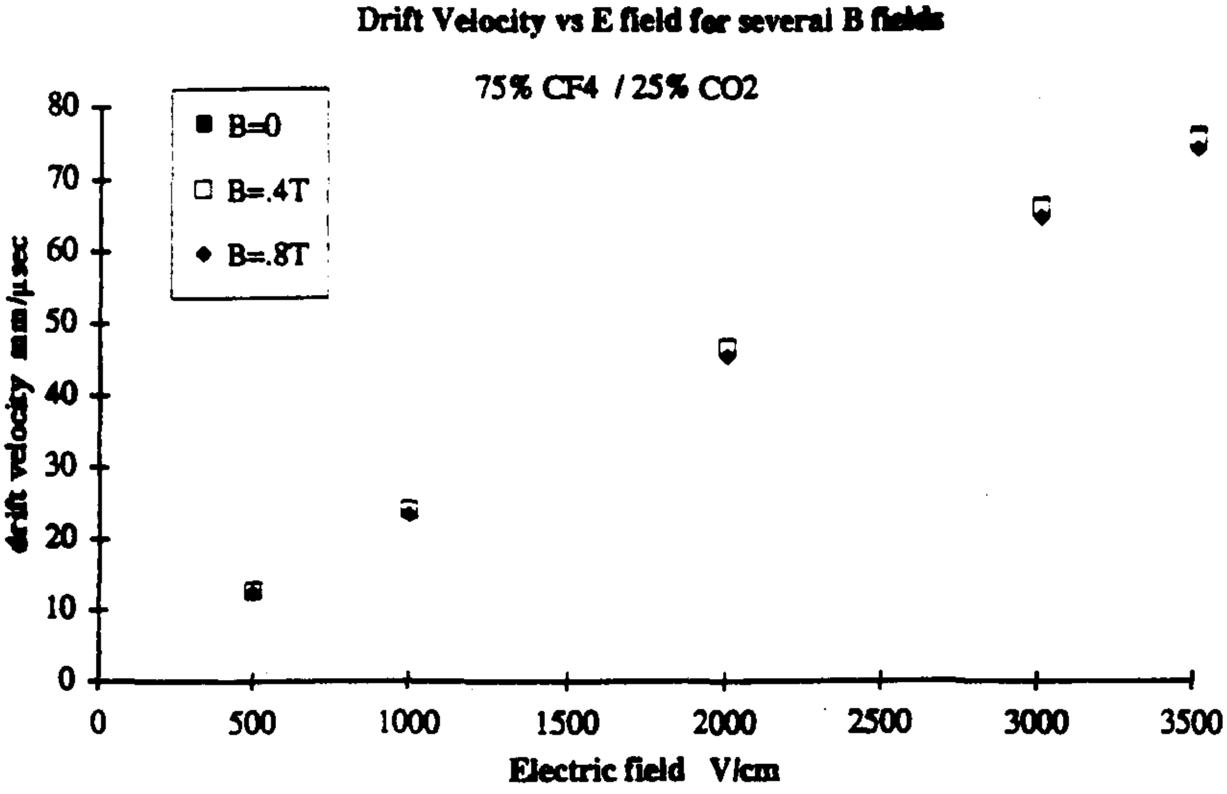


Figure 7 *50/50* $CF_4 - CO_2$ *drift velocity and Lorentz angle*



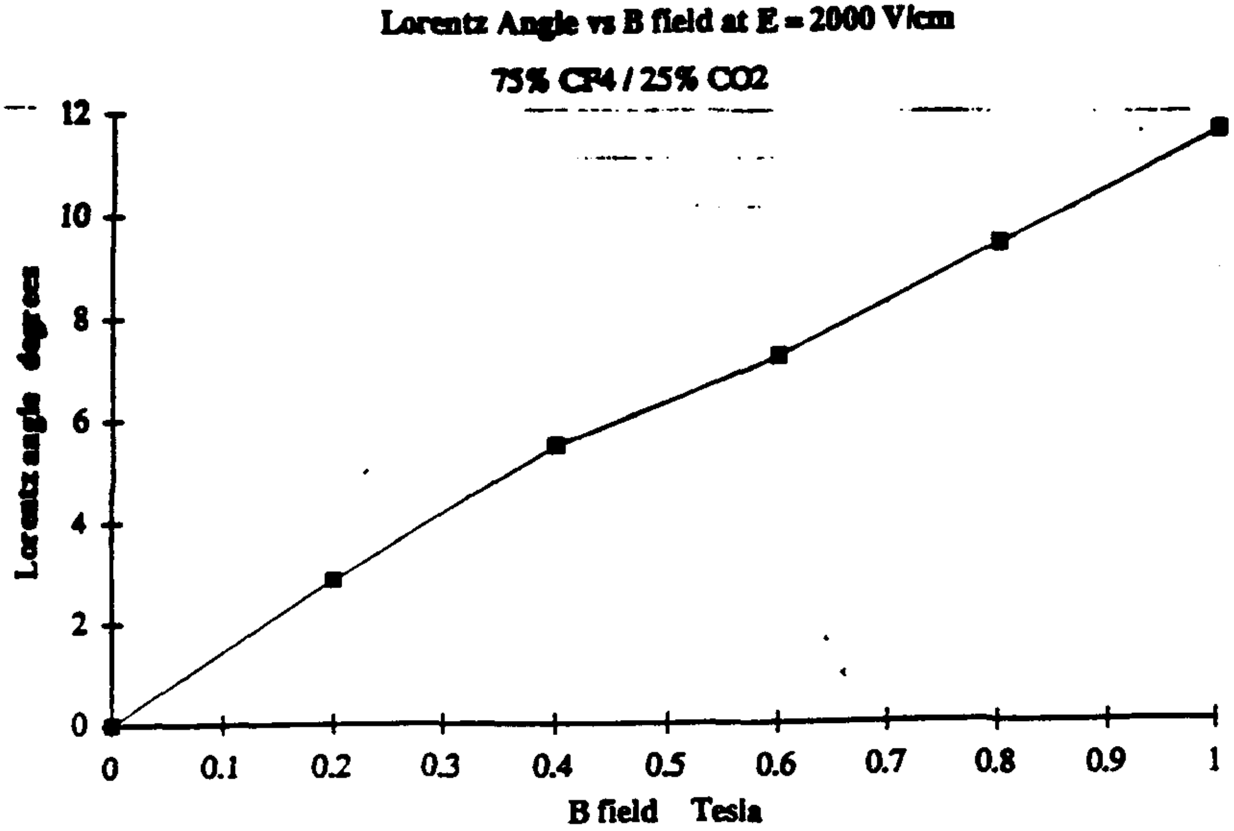


Figure 8 *75/25 $CF_4 - CO_2$ drift velocity and Lorentz angle*