Drift chamber gas and amplifier-discriminator

Introduction

- Time resolution ≈ 1ns
- Dynamic range up to 1:200
- Charge output: from 4 to 40 fC (?)
- Low sensitivity to pressure variation in range: 1000±20mbars
- Low sensitivity to temperature variation in range: 295±5Kº

Hall D electronics

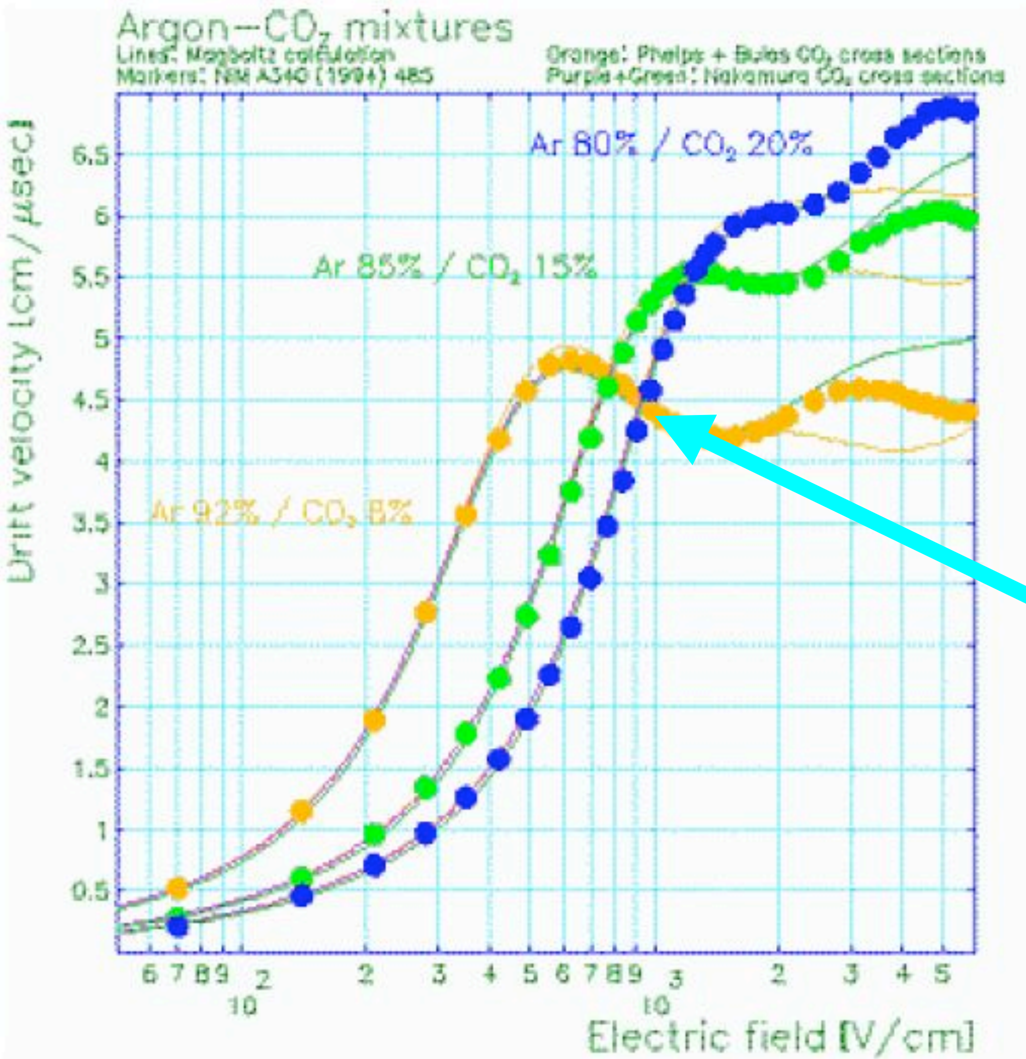
Detector type	Photon tagger	Vertex tracker	Straw tubes	Forward Drifts	Cerenkov	TOF	Barrel calorimeter	Forward calorimeter	Backward veto
Signal Source	PMT	VLPC	Straw tube	anode (A) cathode (C)	PMT	PMT	PMT (P) ? HPD (H) ? MCP (M) ?	PMT	PMT
Channel count	250	2000	3400	2900 (A) 5800 (C)	40	320	600	2500	20
FADC	yes	no	yes (log)	no (A) yes (C)	yes	yes	yes	yes	yes
TDC	yes	yes	no	yes (A) no (C)	yes	yes	yes	no	yes
Typical charge	~ 1 nC	~ 1 pC	~ 40 fC	~ 20 fC (A) ~ 4 fC (C)	~ 10 pC	~ 1 nC	~ 1 nC (P) ~1 pC (H) ~1 nC (M)	~ 1 nC	~ 1 nC
Energy resolution	Given by segment	N/A	20%	N/A (A) 20% (C)	N/A but 10 p.e.	N/A	5%/√E	5%/√E	5%/√E
Time resolution	~ 100 ps	~ 1 ns	~ 1 ns	~ 1 ns	~ few ns	~ 80 ps	~ 200 ps with averaging	~ 1 ns	~ 1 ns
Dynamic range factor	5	5	50	200	10	10	1000	1000	100
Packaging constraints & issues	none	cryogenics	Preamps at upstream end and cabling inside BCAL	Preamps within barrel and B-field and cabling	Shielding of PMT's	Shielding of PMT's	Operation in B-field and choice of PMT,HPD or MCP	none	none
Known solutions for electronics	Used by CLAS	D0 at FNAL & look at VLPC alternatives	Look at existing straw tube solutions	standard	LASS CLAS	Prototypes tested at IHEP	KLOE	This detector used in BNL E852	standard
Institutional responsible	Glasgow Catholic U U Conn	FIU ODU	CMU	Ohio JLab	IHEP	IU IHEP	Regina	IU	FSU

Gas mixture

We will compare:

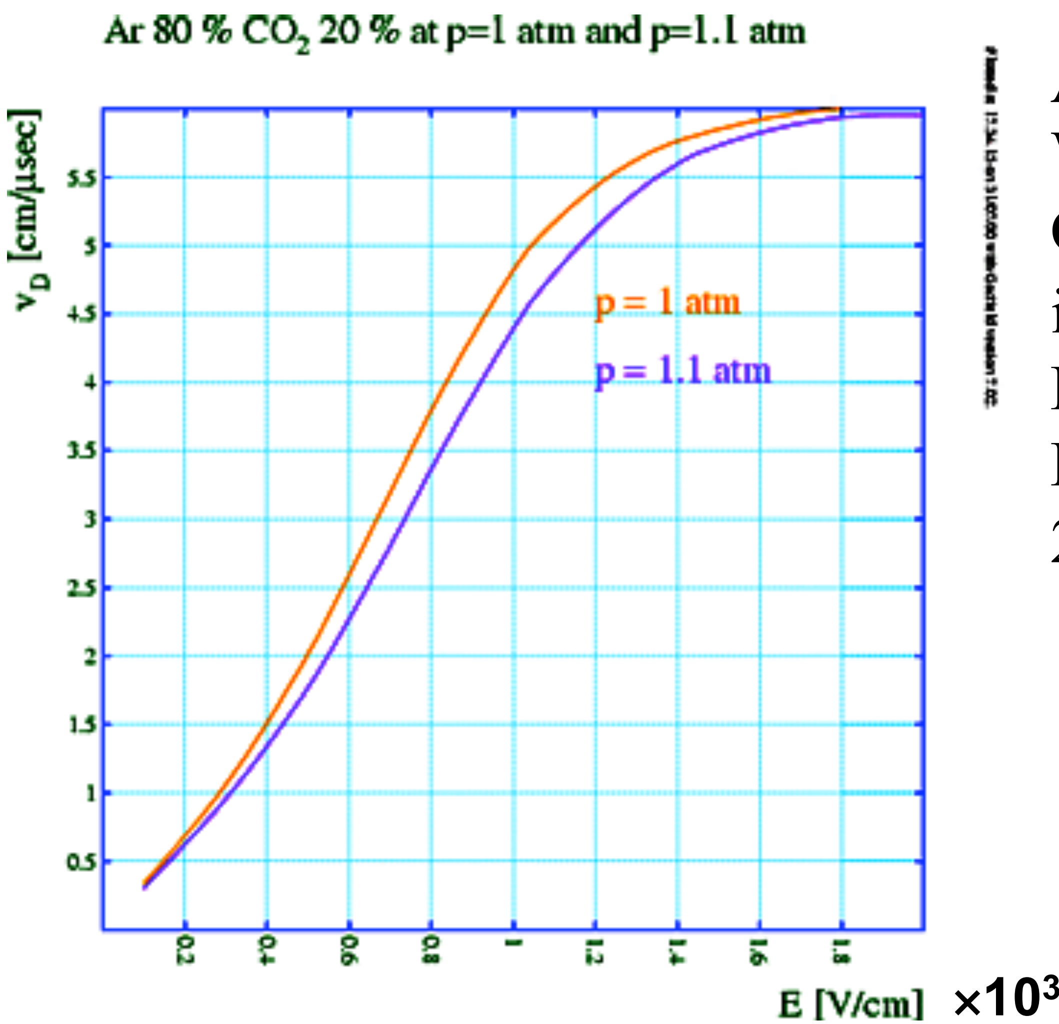
1. Ar + CO_2 (80% + 20%)
2. Ar + C_2H_6 (50% + 50%)
3. Ar + CO_2 + CH_4 [a] (90% + 5% + 5%)
   [b] (90% + 9% + 1%)

1. Ar + CO_2



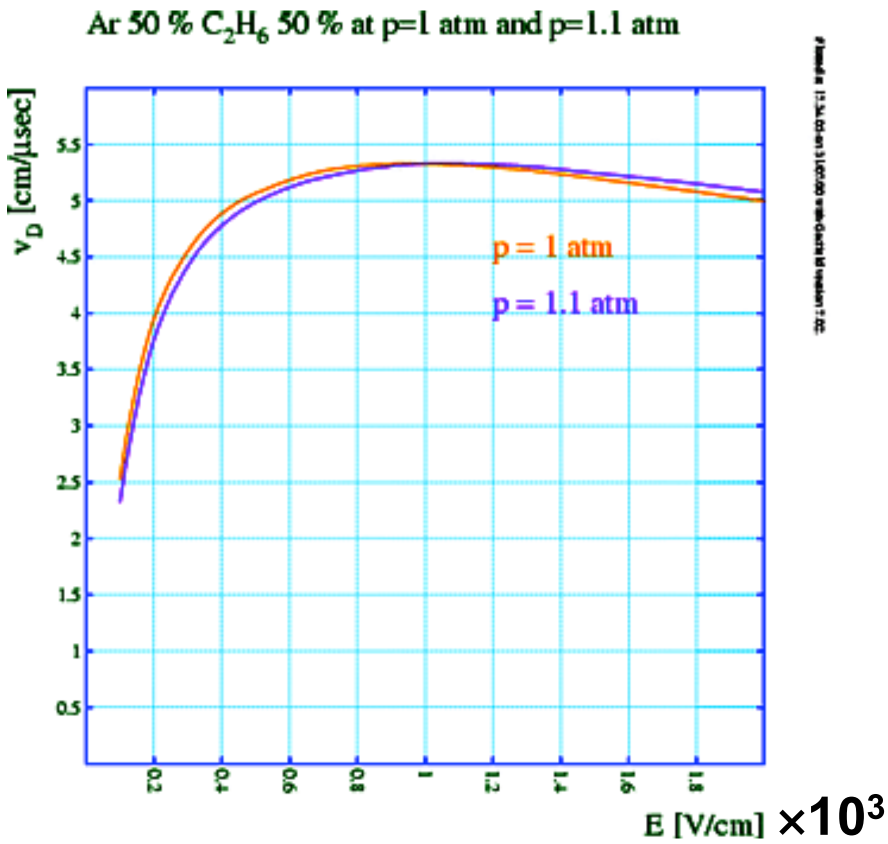
Drift velocity
Is sensitive to field

Pressure and temperature sensitivity



Around E=1kV/cm,
We have $\Delta x \approx 2\mu m/mbar$
Or $\Delta x \approx \pm 40\ \mu m$ for
interval (1000±20)mbars.
From thermodynamic
PV=nRT, or effect of
20mbar is equal to 6Kº.

2. Ar + C_2H_6 (50% + 50%)

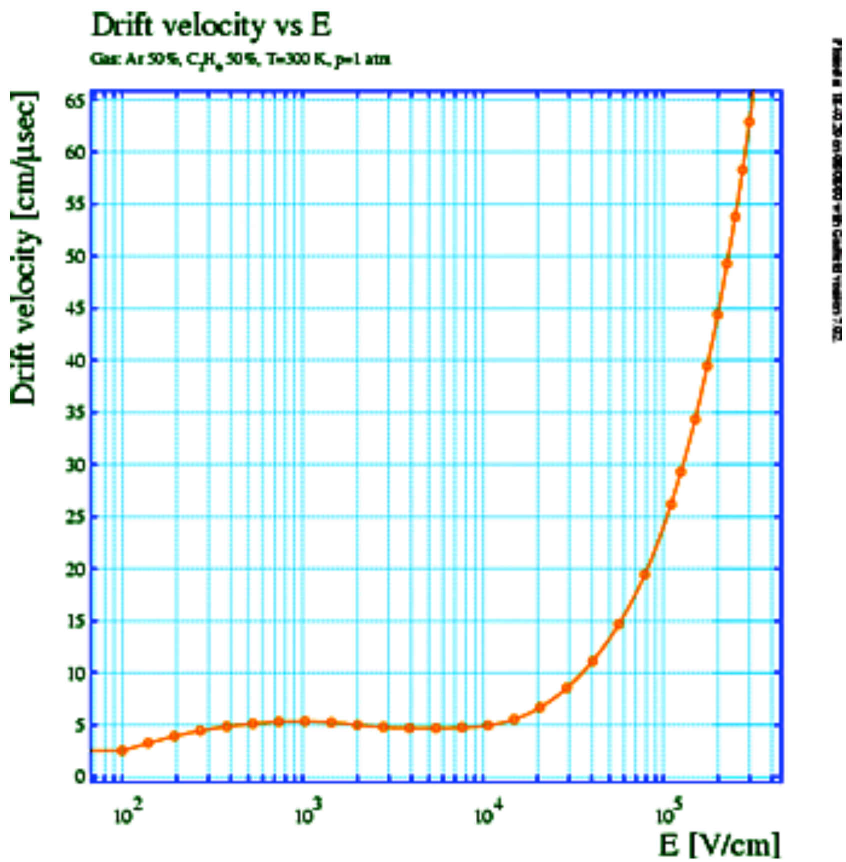


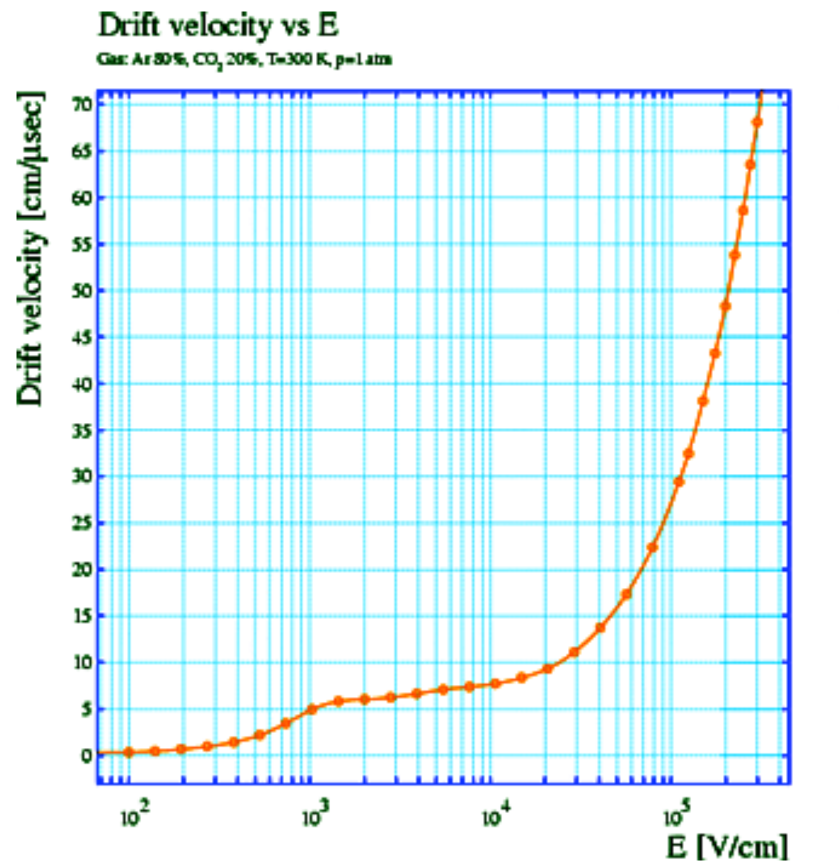
This is a classic mixture, it has a perfect stability around E = 1kV/cm point.

dx(K)/dK ≈ 0

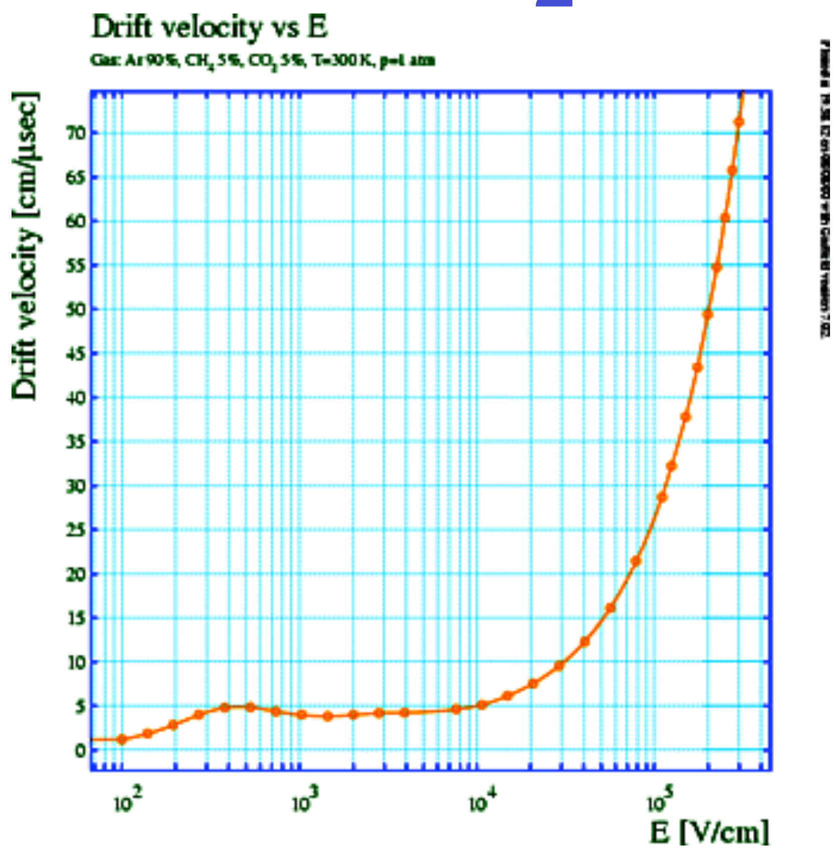
dx(P)/dP ≈ 0

Drift velocity vs. E comparison

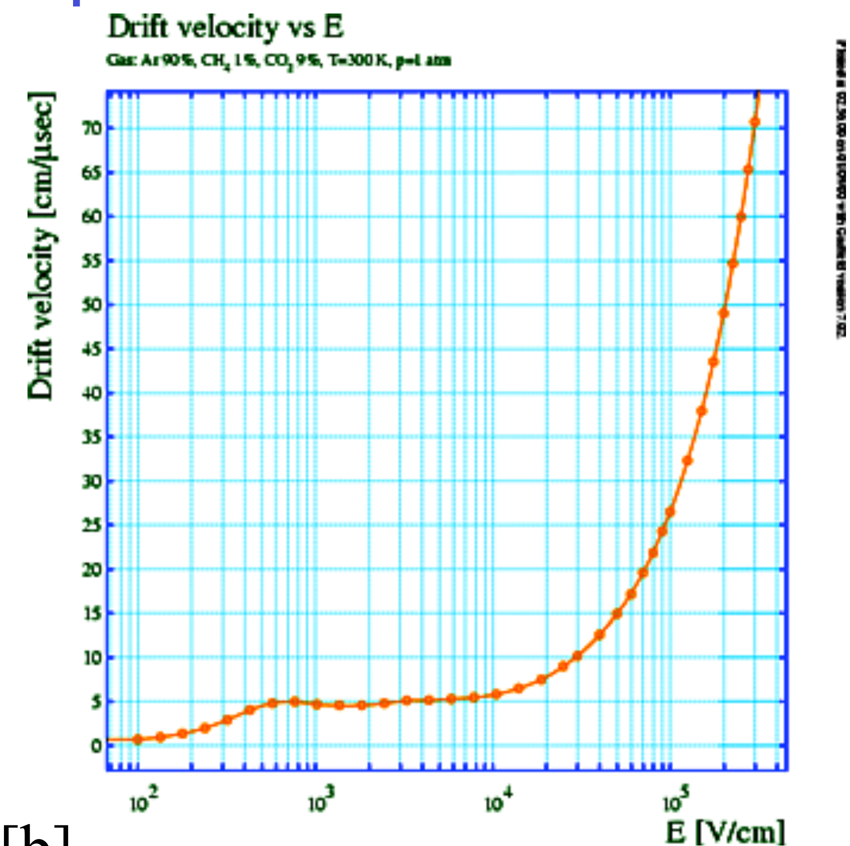




3. $Ar + CO_2 + CH_4$



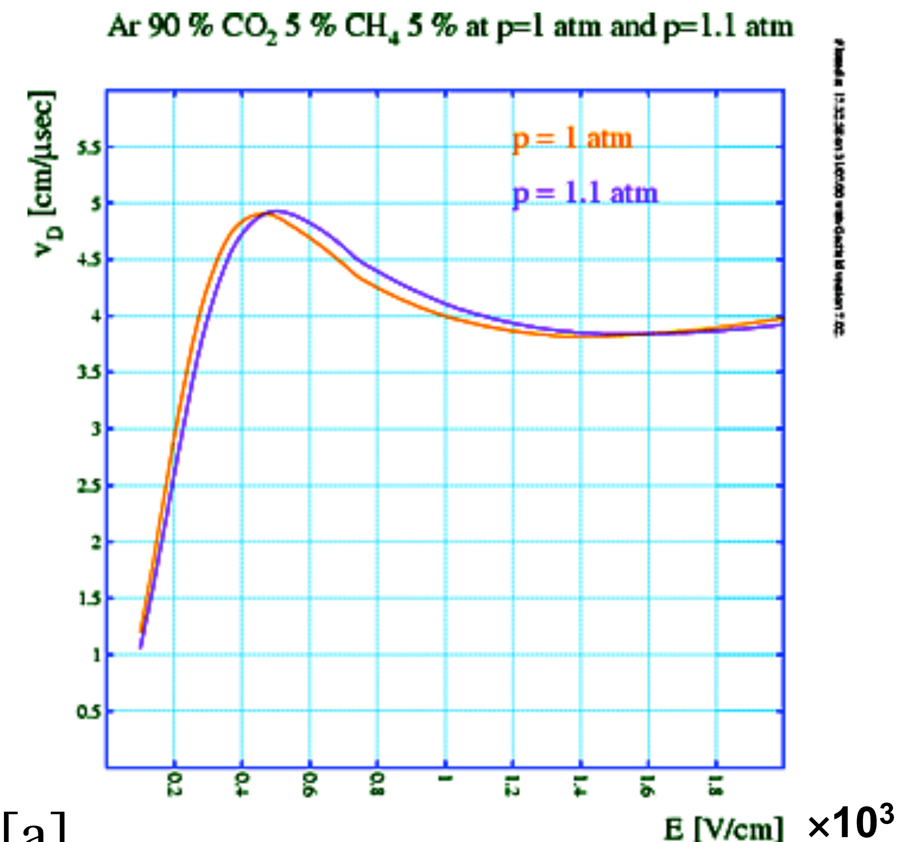
[a]



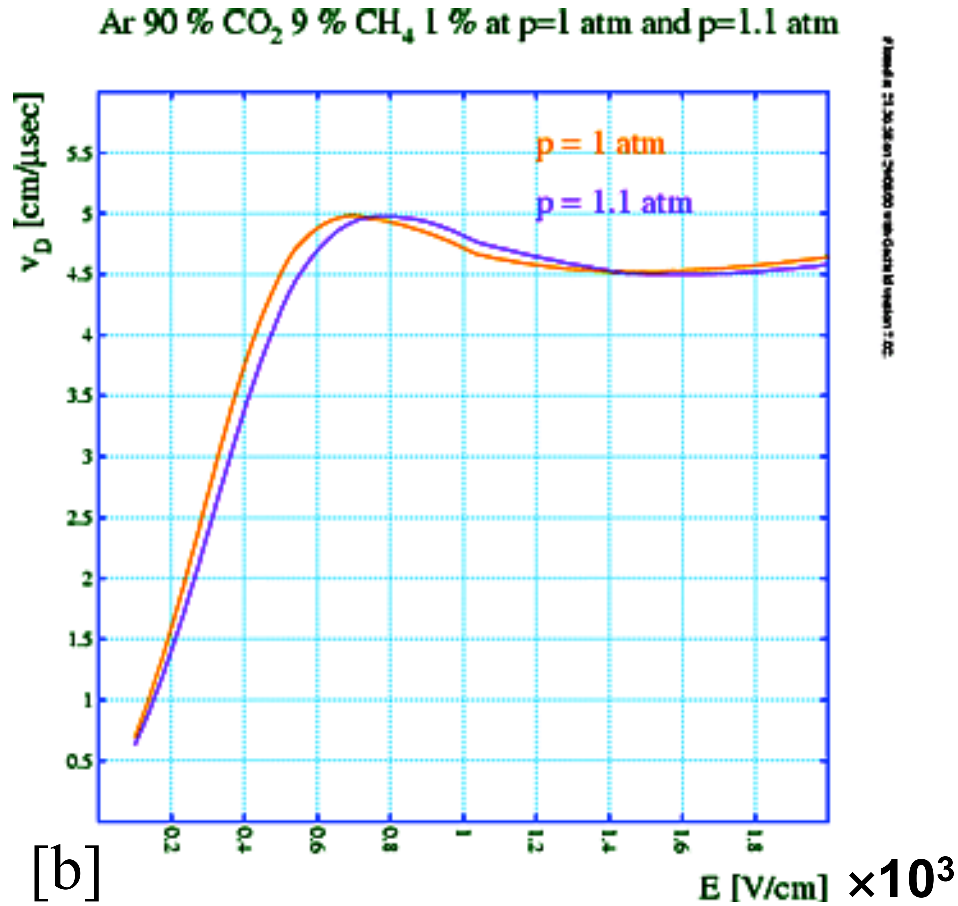
[b]

[a] $Ar + CO_2 + CH_4$ => 90%+5%+5%

[b] $Ar + CO_2 + CH_4$ => 90%+9%+1%



[a]



[b]

Both mixtures shows a lower pressure/temperature sensitivity then (Ar + CO2). Mixture [b] has a near zero effect of pressure/temperature around E=0.8kV/cm

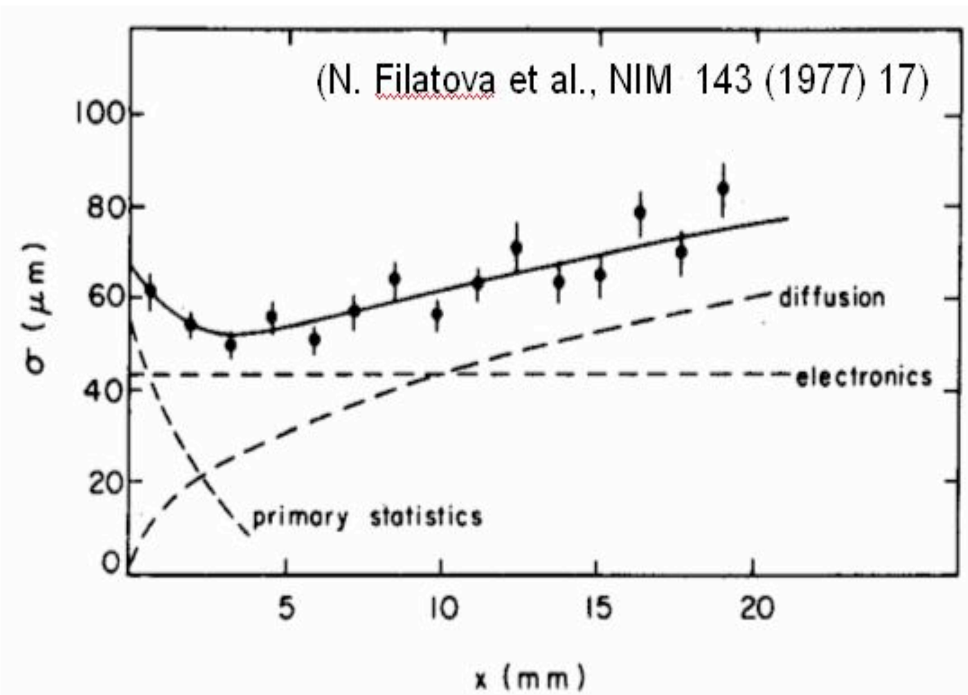
Conclusion:

$(Ar + CO_2)$	$Ar + 5\%CO_2 + 5\%CH_4$	$Ar + 9\%CO_2 + 1\%CH_4$
$\Delta x \approx \pm 40\ \mu m$ vs. (1000 ± 20)mbar or $295 \pm 5K^{o}$, at E=1kV/cm Vd =4.5cm/μsec $\delta x = 200\ \mu m$	$\Delta x \approx \pm 30\ \mu m$ vs. (1000 ± 20)mbar or $295 \pm 5K^{oo}$, at E=1kV/cm Vd =4.0cm/μsec $\delta x = 180\ \mu m$	$\Delta x \approx \pm 20\ \mu m$ vs. (1000 ± 20)mbar or $295 \pm 5K^{oo}$, at E=1kV/cm Vd =4.7cm/μsec $\delta x = 180\ \mu m$

Effect negligible for (Ar 50 % C_2H_6 50%), $\delta x = 140\ \mu m$
There is a stable interval for $(Ar + 9\%CO_2 + 1\%CH_4)$ at E=0.7-0.8kV/cm and E=1.4-1.6kV/cm. There is no stable interval for $(Ar + CO_2)$ below E=2kV/cm

* δx is the longitudinal diffusion

Amplifier-discriminator

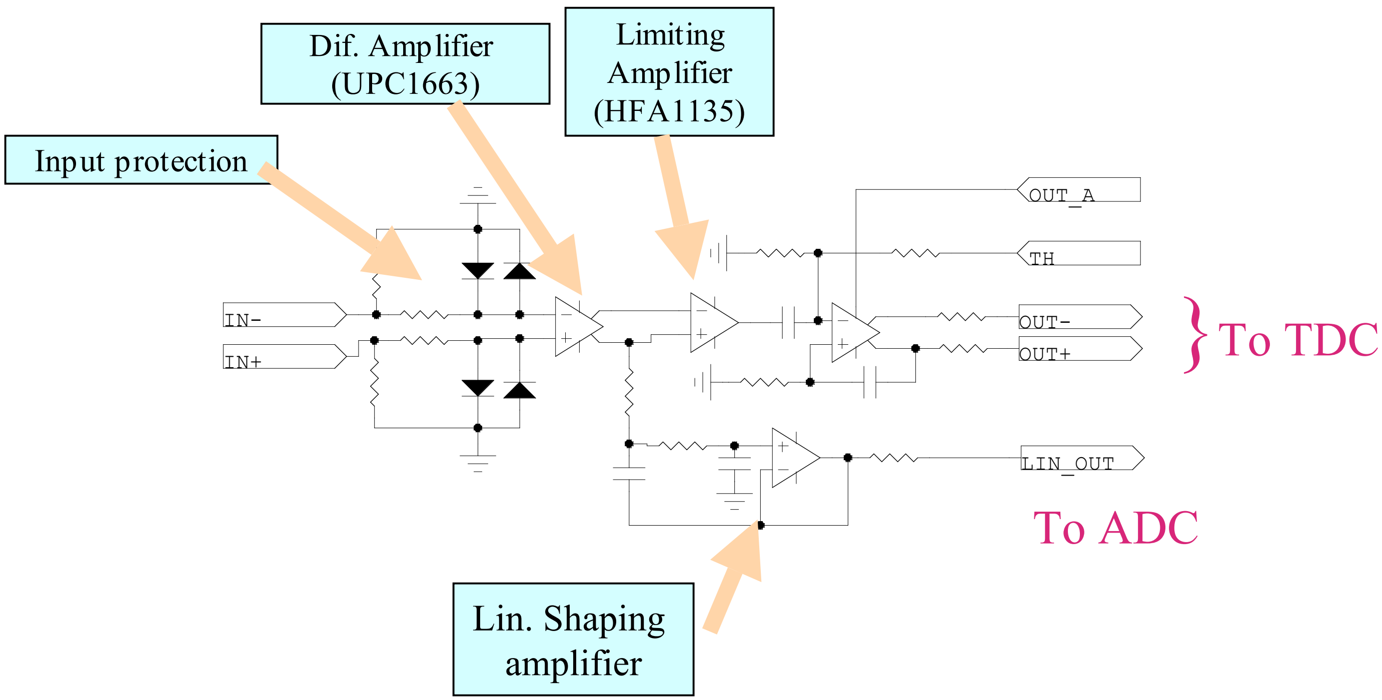


- All four gas mixture produce the same (±10% difference) amount of e-ion pairs (90-110) per 1cm of gas.
- Effect of diffusion is dominate over other

Gas mixtures gain

- The classic 50% Ar + 50% C_2H_6 and 80%Ar + 20% $CO_{2,}$ are similar.
- The mixture [a] 90% Ar + 5% CO_2+ 5%CH_4 has a factor 4 higher gain
- The mixture [a] 90% Ar + 9% CO_2+ 1%CH_4 , about 60 higher gain.

Generic amplifier-discriminator circuit



Conclusion and suggested tests.

• With current drift chamber prototype test a three component gas mixture
• Design or find design a proto-amplifier-discriminator with output amplitude control (positive FB control).