Gas Detectors

F.Sauli, Principles of operation of multiwire proportional chambers

https://cds.cern.ch/record/117989/files/CERN-77-09.pdf

Properties of several gases used in proportional counters (from different sources, see the bibliography for this section). Energy loss and ion pairs per unit length are given at atmospheric pressure for minimum ionizing particles

Gas	Z	A	δ (g/cm^3)	E_{ex}	E_i (eV)	I_0	W_i	dE/dx ($MeV/g\ cm^{-2}$)	dE/dx (keV/cm)	n_p (i.p./cm) a)	n_T (i.p./cm) a)
H_2	2	2	8.38×10^{-5}	10.8	15.9	15.4	37	4.03	0.34	5.2	9.2
He	2	4	1.66×10^{-4}	19.8	24.5	24.6	41	1.94	0.32	5.9	7.8
N_2	14	28	1.17×10^{-3}	8.1	16.7	15.5	35	1.68	1.96	(10)	56
O_2	16	32	1.33×10^{-3}	7.9	12.8	12.2	31	1.69	2.26	22	73
Ne	10	20.2	8.39×10^{-4}	16.6	21.5	21.6	36	1.68	1.41	12	39
Ar	18	39.9	1.66×10^{-3}	11.6	15.7	15.8	26	1.47	2.44	29.4	94
Kr	36	83.8	3.49×10^{-3}	10.0	13.9	14.0	24	1.32	4.60	(22)	192
Xe	54	131.3	5.49×10^{-3}	8.4	12.1	12.1	22	1.23	6.76	44	307
CO_2	22	44	1.86×10^{-3}	5.2	13.7	13.7	33	1.62	3.01	(34)	91
CH_4	10	16	6.70×10^{-4}		15.2	13.1	28	2.21	1.48	16	53
C_4H_{10}	34	58	2.42×10^{-3}		10.6	10.8	23	1.86	4.50	(46)	195

a) i.p. = ion pairs

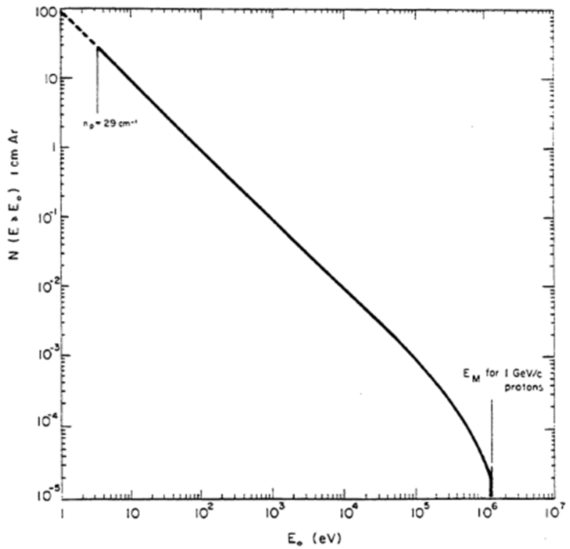
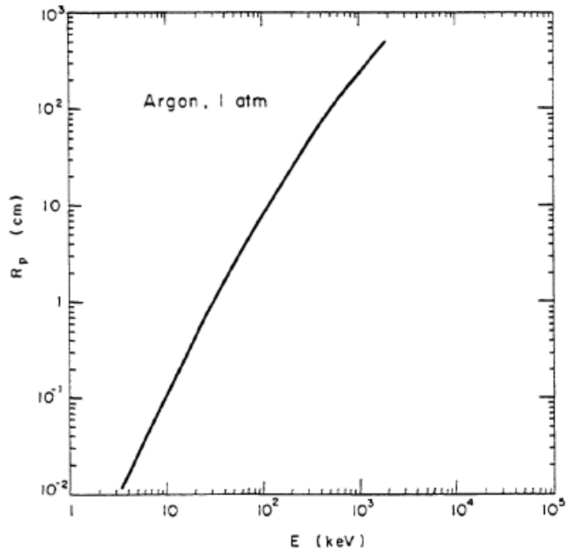


Fig. 4 Computed number of δ electrons ejected at an energy larger than or equal to E_0, as a function of E_0, in 1 cm of argon at normal conditions. The average number of primary ionizing collisions (29 per cm) and the maximum allowed energy transfer for 1 GeV/c protons are shown.



j. 5 Range of electrons in argon, at normal conditions as a function of energy, deduced from measurement in light materials[8)]

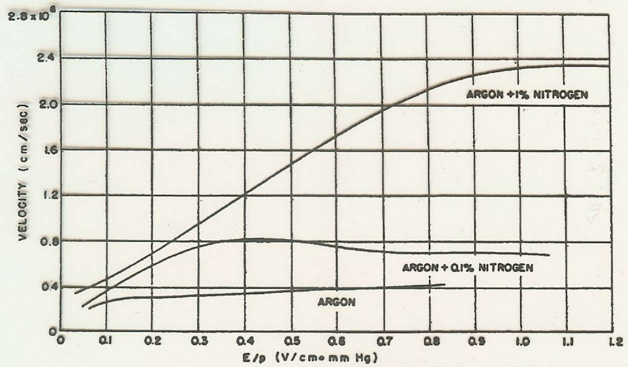


Fig. 25 Drift velocity of electrons in [redacted], and in argon with small added quantities of nitrogen. The very large effect on the velocity for small additions is apparent[22]).

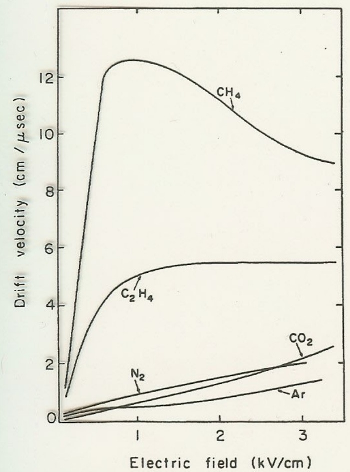


Fig. 26 Drift velocity of electrons in several gases at normal conditions[12,22,23])

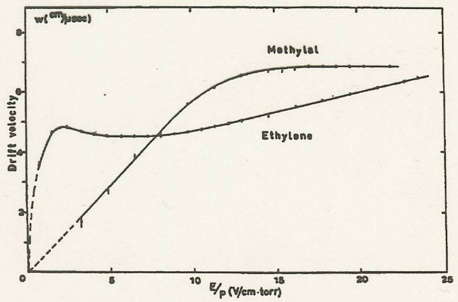
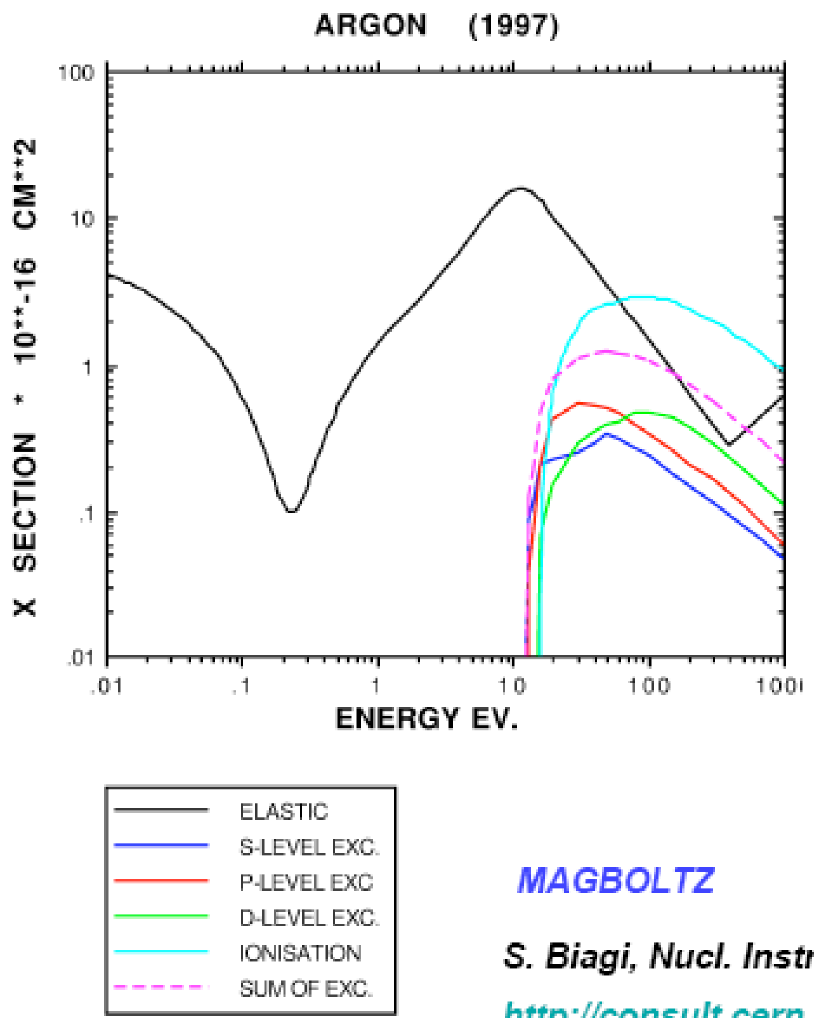
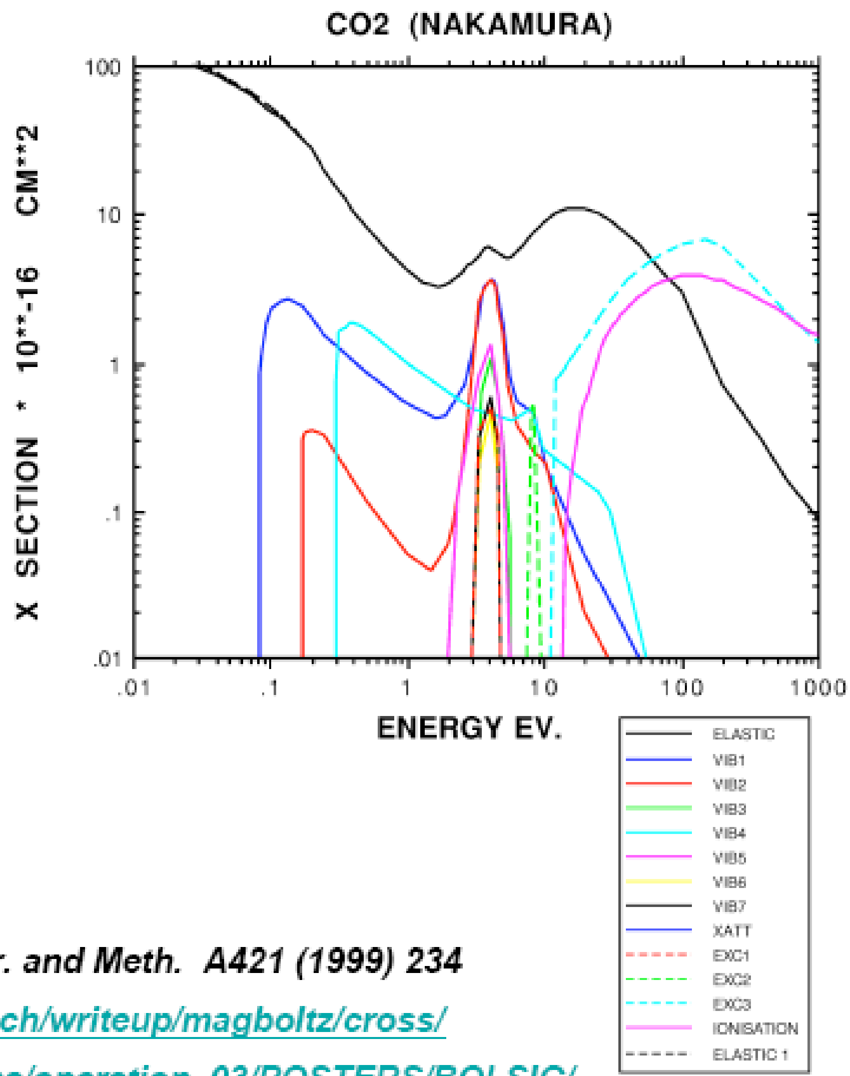


Fig. 27 Drift velocity of electrons in methylal [$(OCH_3)_2CH_2$] and in ethylene (C_2H_4)[24])

CHARGE TRANSPORT DETERMINED BY ELECTRON-MOLECULE CROSS SECTION:





MAGBOLTZ

S. Biagi, Nucl. Instr. and Meth. A421 (1999) 234

http://consult.cern.ch/writeup/magboltz/cross/

http://cpa94.ups-tlse.fr/operations/operation_03/POSTERS/BOLSIG/

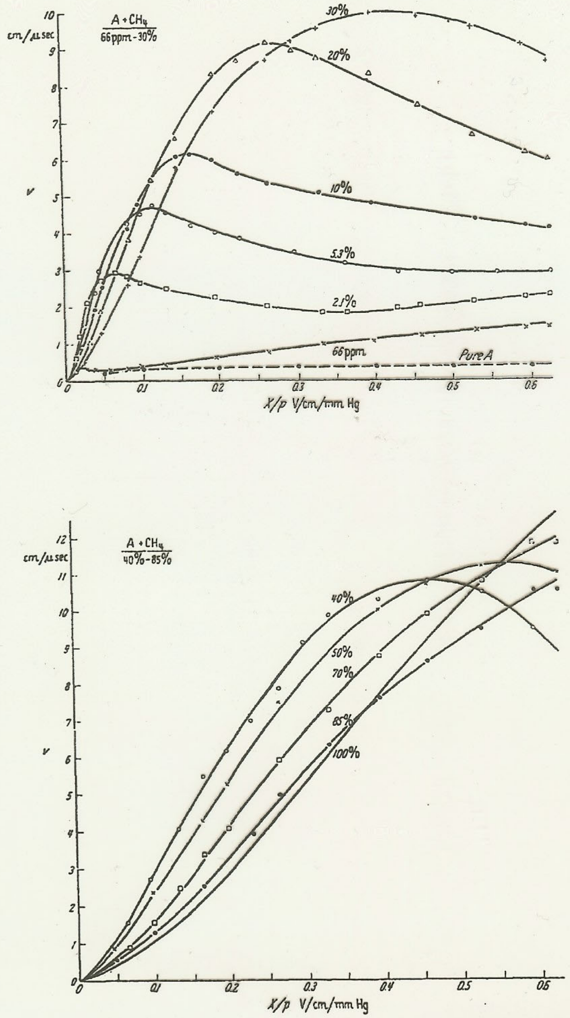
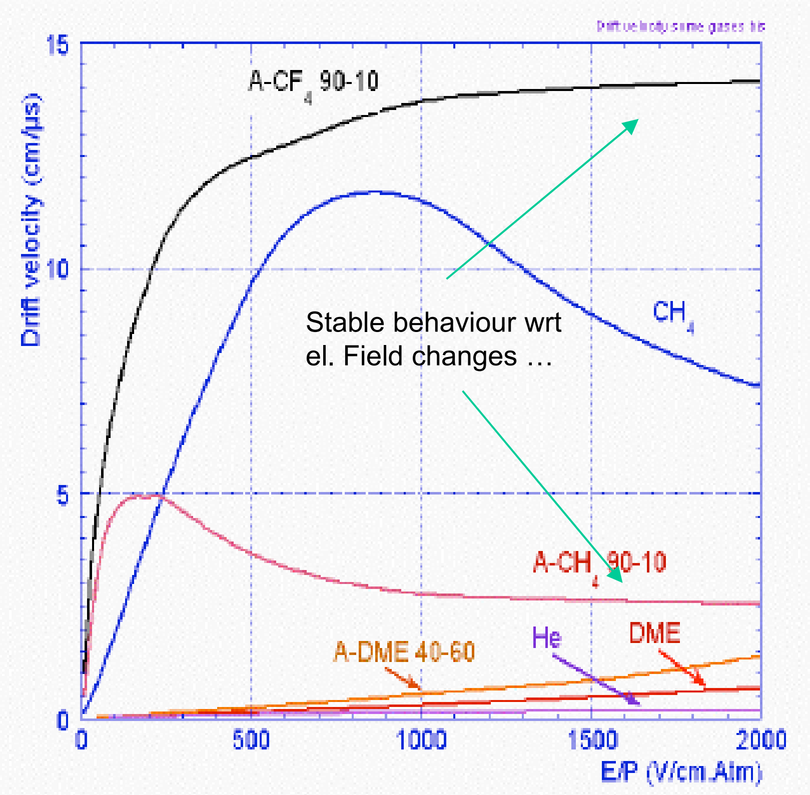


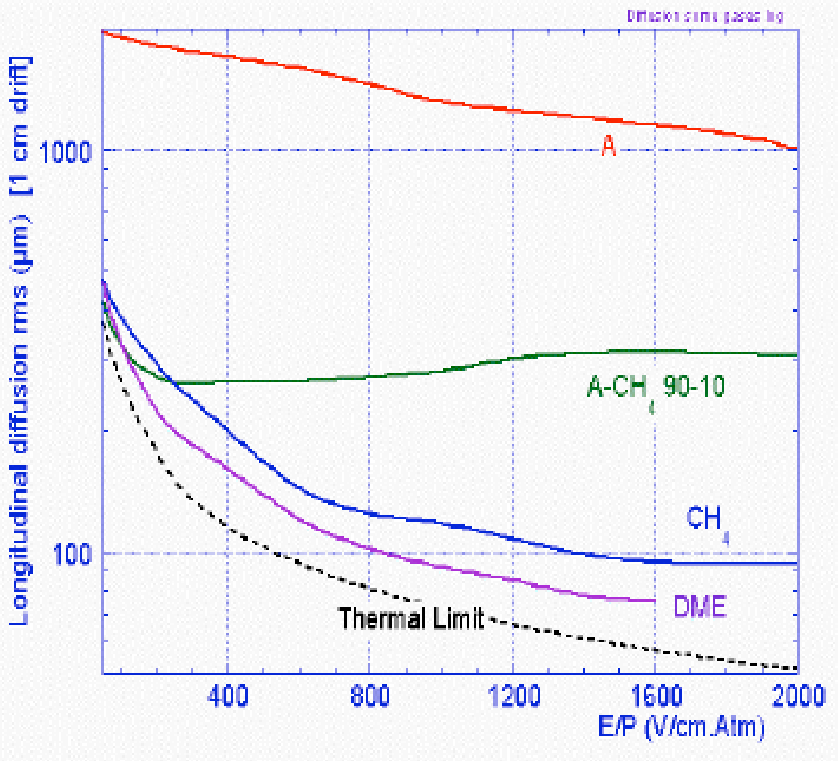
Fig. 28 Drift velocity of electrons in several argon-methane mixtures[12])

LARGE RANGE OF DRIFT VELOCITIES AND DIFFUSIONS

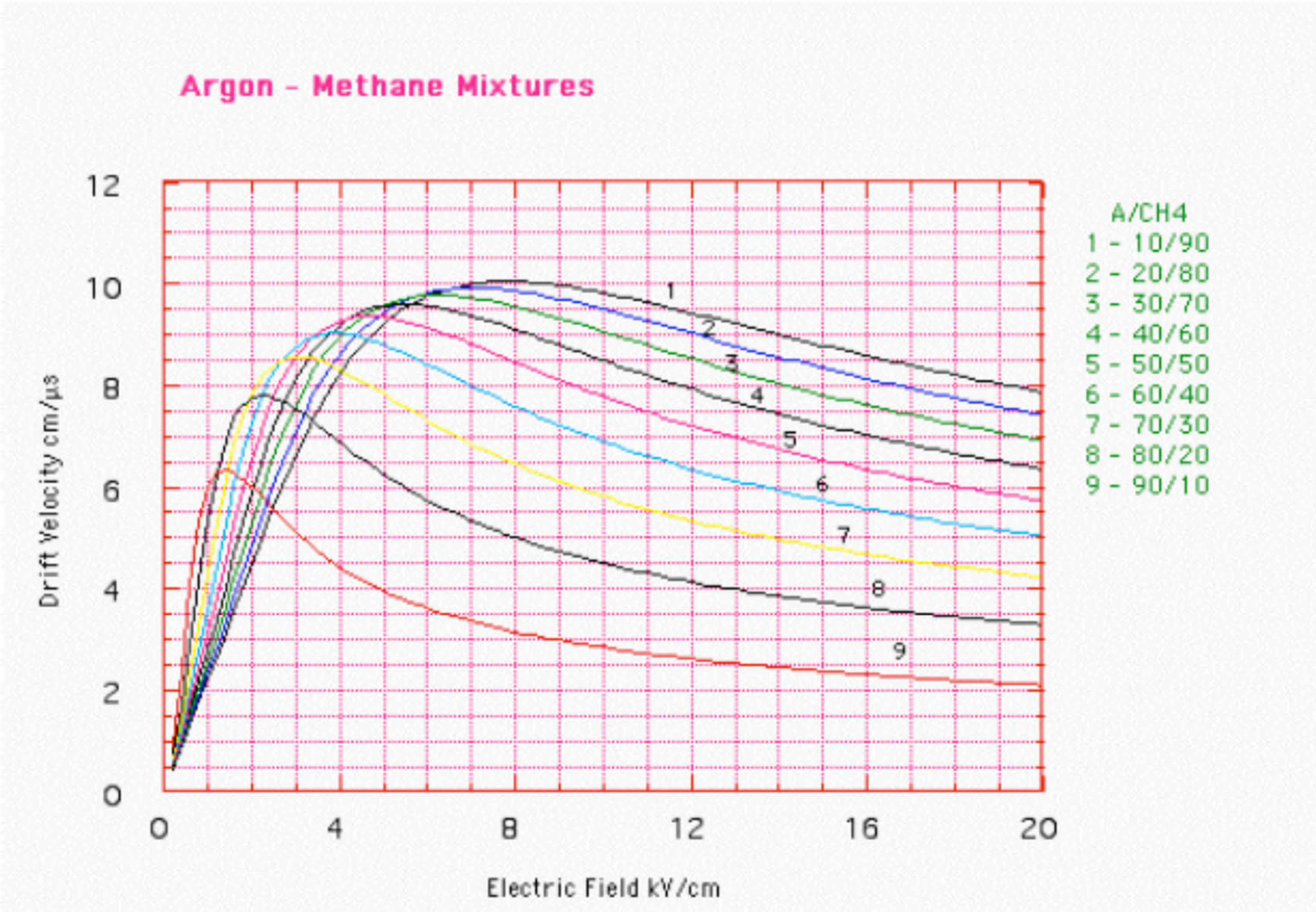
DRIFT VELOCITY:



DIFFUSION:



COMPUTED DRIFT VELOCITY IN MIXTURES



http://consult.cern.ch/writeup/garfield/examples/gas/trans2000.html#elec

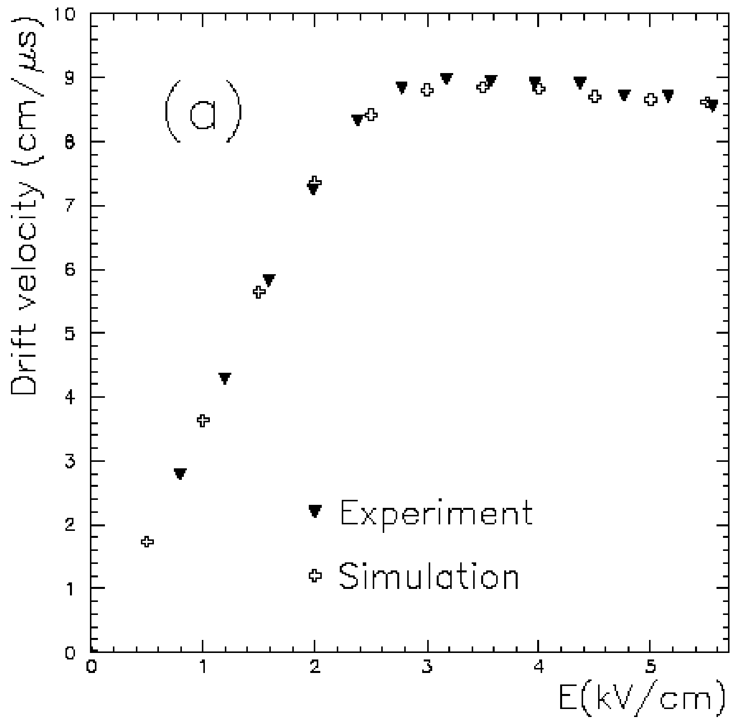
Velocita’ di deriva degli elettroni

Velocita’ di deriva in una miscela
$Ar/CO_2/CF_4$ (60/20/20).

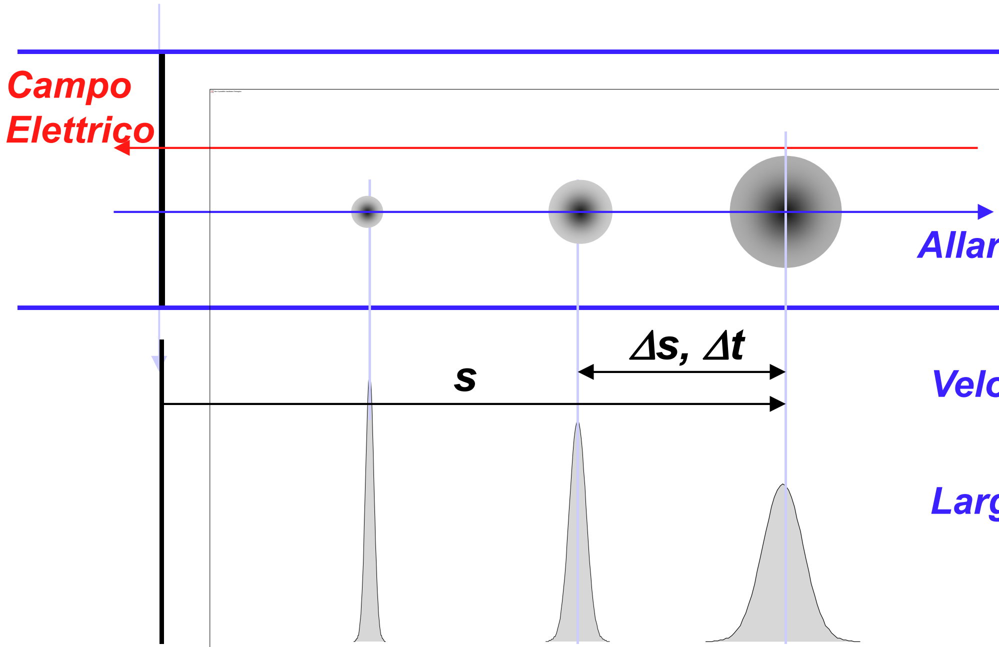
Satura a

$w^- \approx 10$ cm/μs
$\Rightarrow$100 μm/ns

3000 volte la velocita’ degli ioni



Deriva e diffusione degli elettroni



Allargamento della regione occupata

Velocita' di deriva: $w = \frac{\Delta s}{\Delta t}$

Larghezza dovuta alla diffusione

$$\sigma = \sqrt{2Dt} = \sqrt{2D\frac{s}{w}}$$

$$\sigma_x = \sigma_1 \sqrt{x}$$

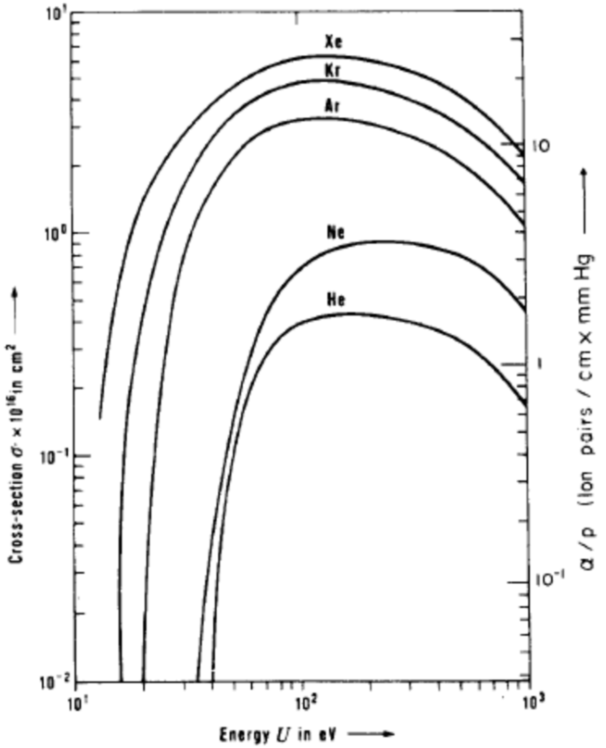


Fig. 45 Cross-section and first Townsend coefficient as a function of electron energy, for noble gases[28]

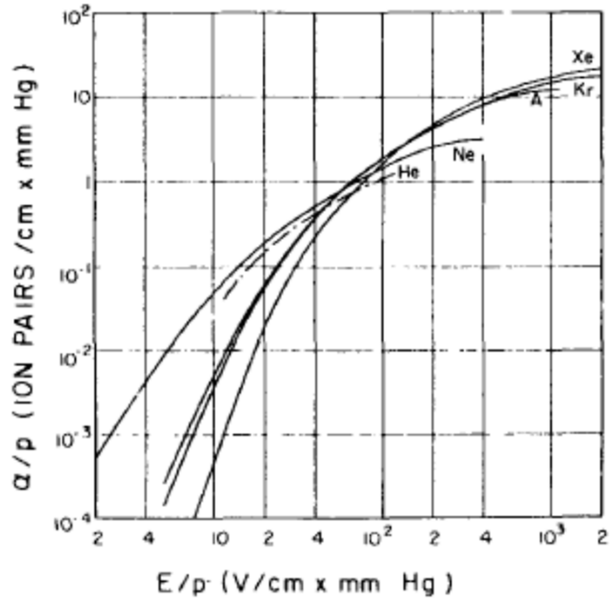
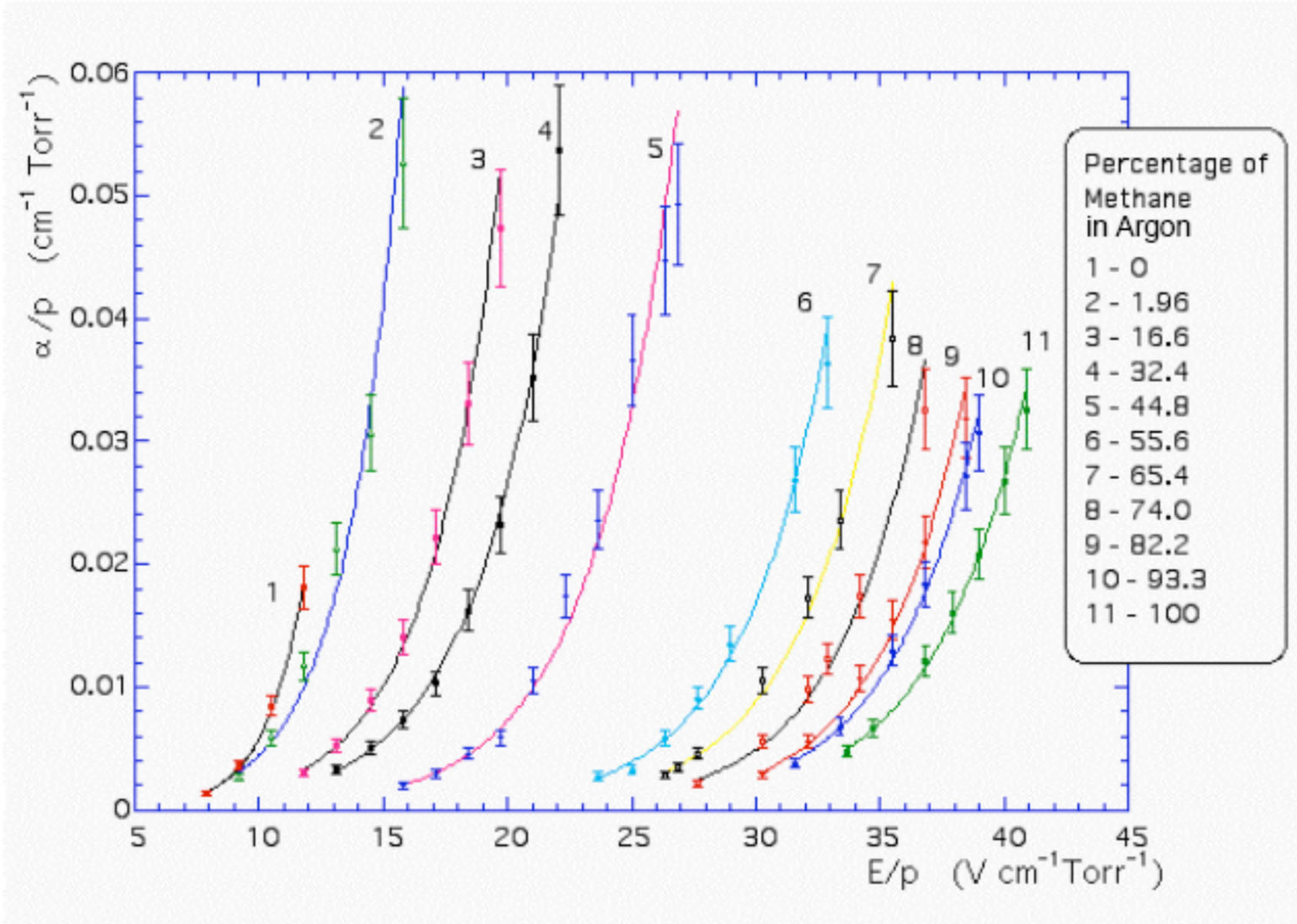


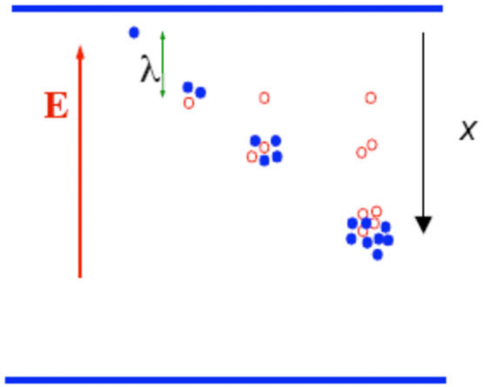
Fig. 44 First Townsend coefficient as a function of the reduced electric field, for noble gases[22]

TOWNSEND COEFFICIENT IN GAS MIXTURES ARGON-CH_4:

T.C. dependence on gas mixture



AVALANCHE MULTIPLICATION IN UNIFORM FIELD

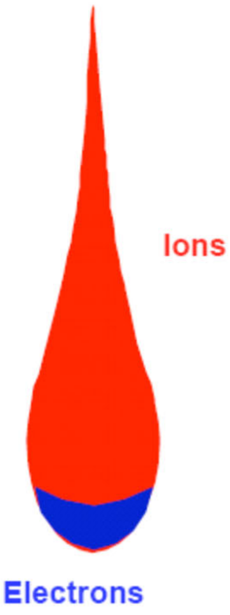


$$dn = n \alpha dx$$

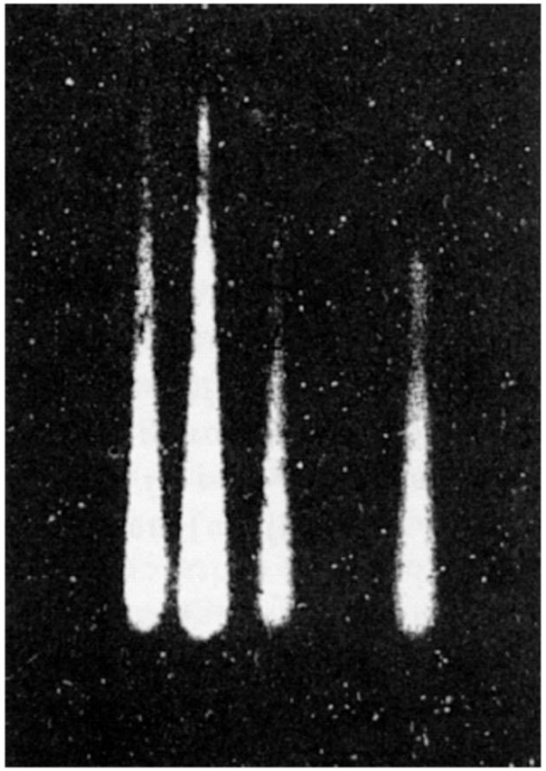
$$n(x) = n_0 e^{\alpha x}$$

Multiplication factor or Gain

$$M(x) = \frac{n}{n_0} = e^{\alpha x}$$



Combined cloud chamber-avalanche chamber:



H. Raether
Electron avalanches and breakdown in gases
(Butterworth 1964)