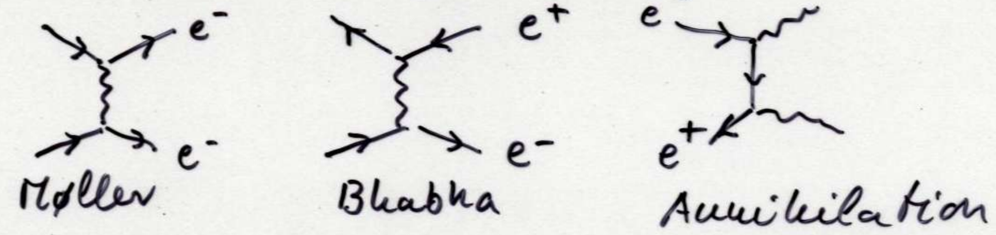
Energieverlust von Elektronen und Positronen

bei kleinen Energien auch



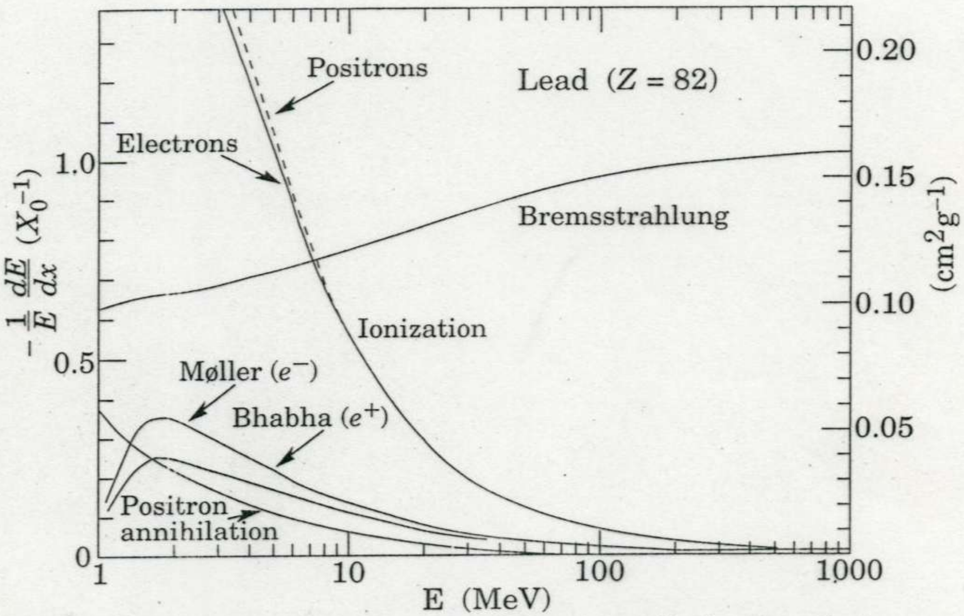


Figure 26.9: Fractional energy loss per radiation length in lead as a function of electron or positron energy. Electron (positron) scattering is considered as ionization when the energy loss per collision is below 0.255 MeV, and as Moller (Bhabha) scattering when it is above. Adapted from Fig. 3.2 from Messel and Crawford, *Electron-Photon Shower Distribution Function Tables for Lead, Copper, and Air Absorbers*, Pergamon Press, 1970. Messel and Crawford use $X_0(\mathrm{Pb}) = 5.82\ \mathrm{g/cm^2}$, but we have modified the figures to reflect the value given in the Table of Atomic and Nuclear Properties of Materials ($X_0(\mathrm{Pb}) = 6.37\ \mathrm{g/cm^2}$).

Photonen

Gesamtabsorptionskoeffizient

$$\sigma_{tot} = \sigma_{Ph} + \sigma_C + \sigma_P$$

$$\mu = \mu_{Ph} + \mu_C + \mu_P \qquad \mu_i = n\sigma_i = \frac{N_A \varrho}{A}\sigma_i$$

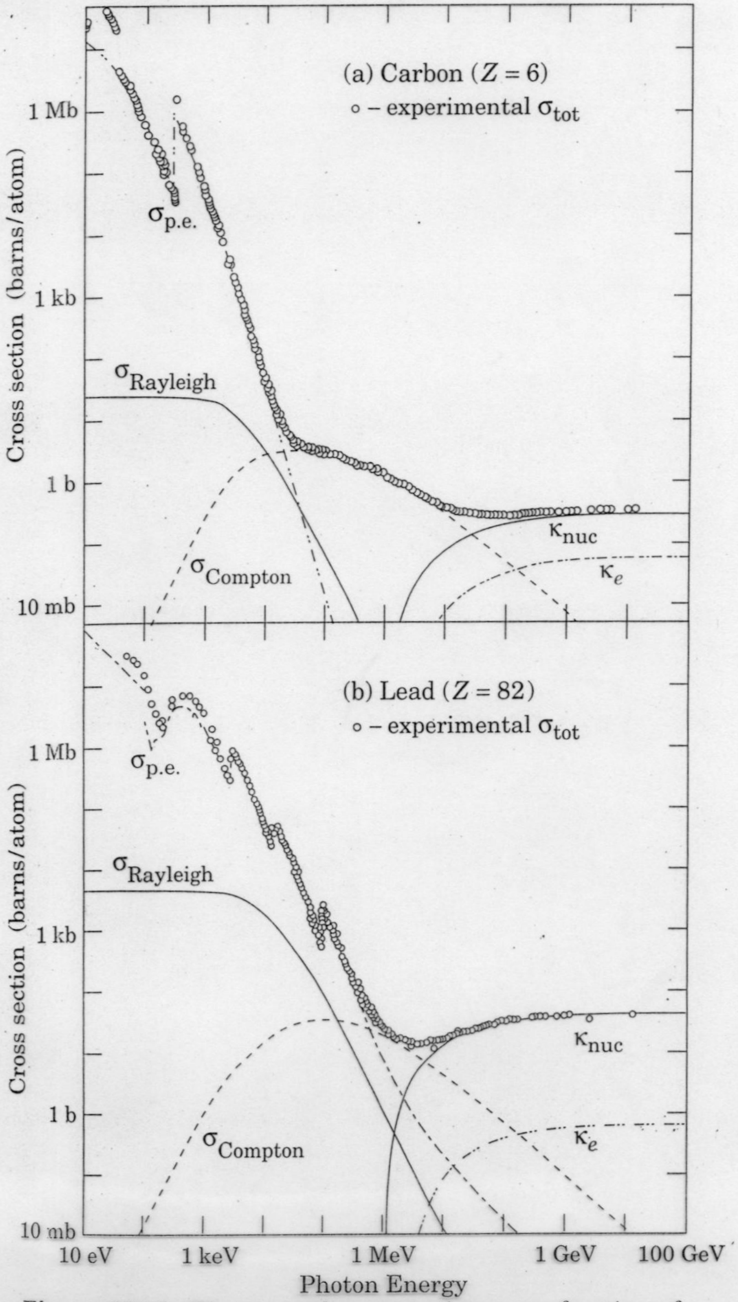
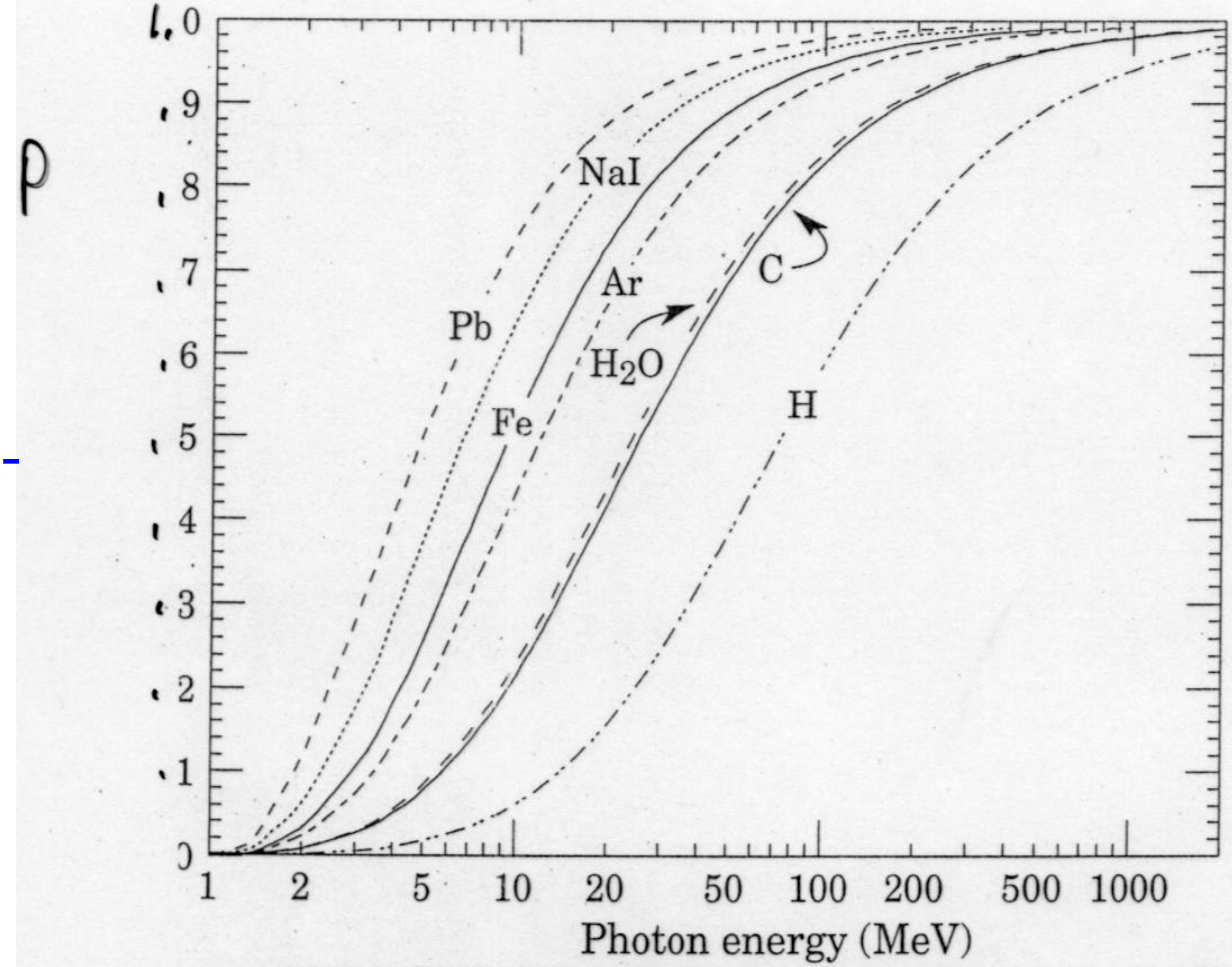


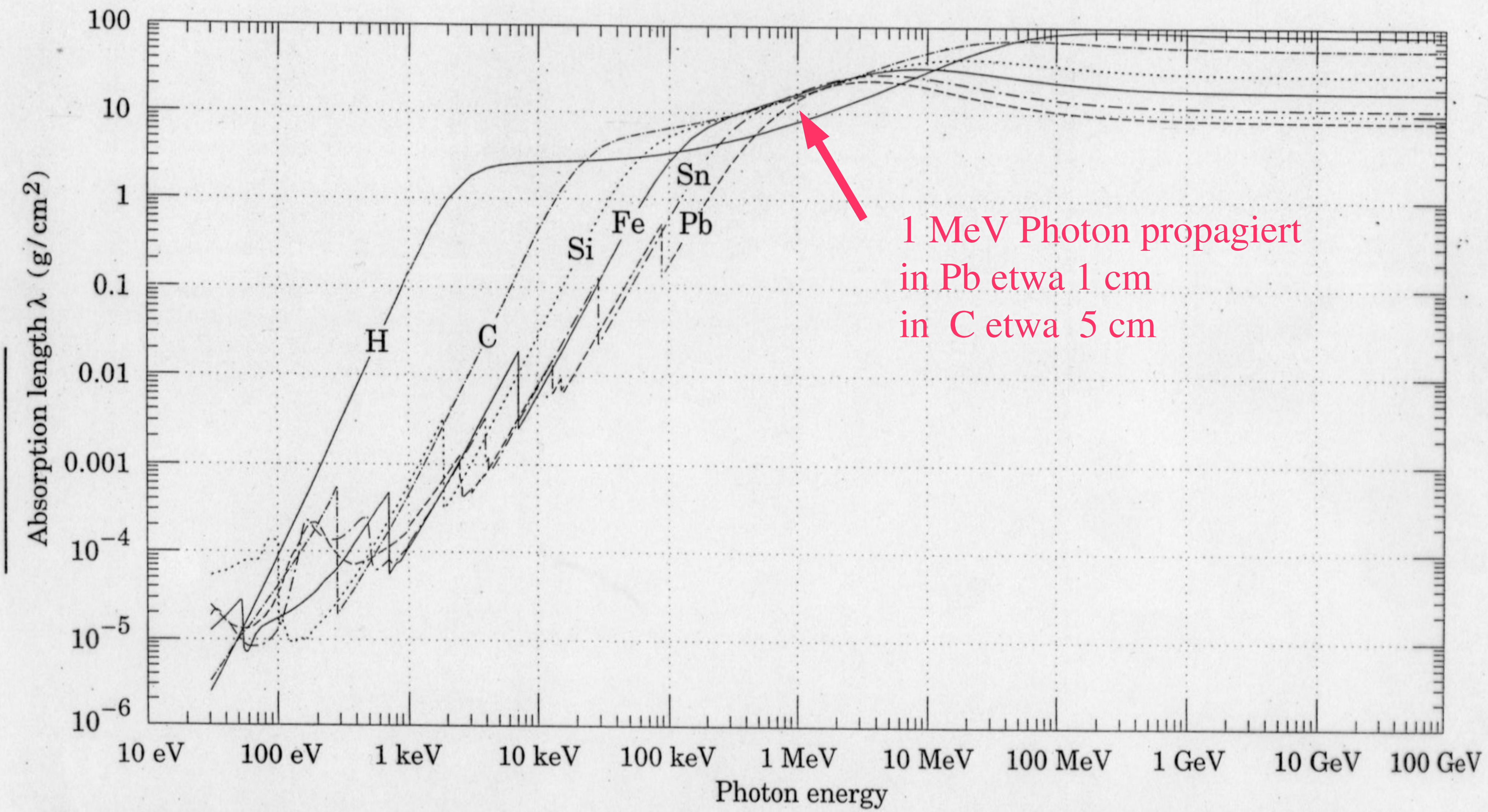
Figure 26.13: Photon total cross sections as a function of energy in carbon and lead, showing the contributions of different

mit wachsender Photon-
Energie wird Paar-
bildung zunehmend
dominant
für Pb über 4 MeV
für H über 70 MeV



gure 26.16: Probability P that a photon interaction will
ult in conversion to an e^+e^- pair. Except for a few-percent
tribution from photonuclear absorption around 10 or 20
V, essentially all other interactions in this energy range result
Compton scattering off an atomic electron. For a photon
enuation length λ (Fig. 26.15), the probability that a given
ton will produce an electron pair (without first Compton
ttering) in thickness t of absorber is $P[1 - \exp(-t/\lambda)]$.

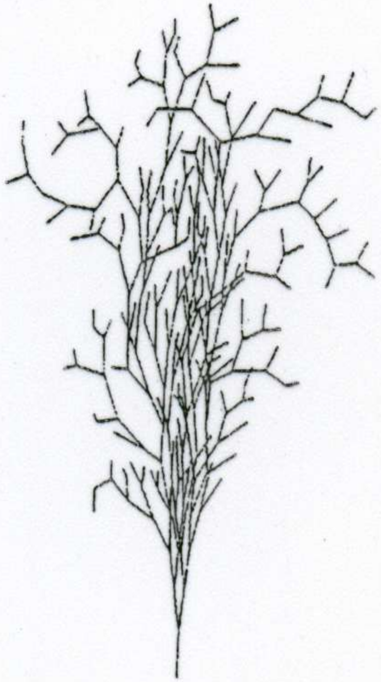
Photon Massenabsorptionslänge $\lambda=1/(\mu/\rho)$ = mittlere freie Weglänge



1 MeV Photon propagiert
in Pb etwa 1 cm
in C etwa 5 cm

Fig. 26.15: The photon mass attenuation length (or mean free path) $\lambda = 1/(\mu/\rho)$ for various elemental absorbers as a function of photon energy. The mass attenuation coefficient is μ/ρ, where ρ is the density. The intensity I remaining after traversal of thickness t (in mass/unit area) is given by $I = I_0 \exp(-t/\lambda)$. The accuracy is a few percent. For a chemical compound or mixture, $1/\lambda_{\text{eff}} \approx \sum_{\text{elements}} w_Z/\lambda_Z$, where w_Z is the proportion by weight of the element with atomic number Z. The processes responsible for attenuation are given in not Fig. 26.9. Since coherent processes are included, not all these processes result in energy deposition. The data for 30 eV $< E <$ 1 keV are obtained from `http://www-cxro.lbl.gov/optical_constants` (courtesy of Eric M. Gullikson, LBNL). The data for 1 keV $< E <$ 100 GeV are from `http://physics.nist.gov/PhysRefData`, through the courtesy of John H. Hubbell (NIST).

Elektromagnetischer Schauer:



Betriebsmoden von Gasdetektoren je nach E-Feld

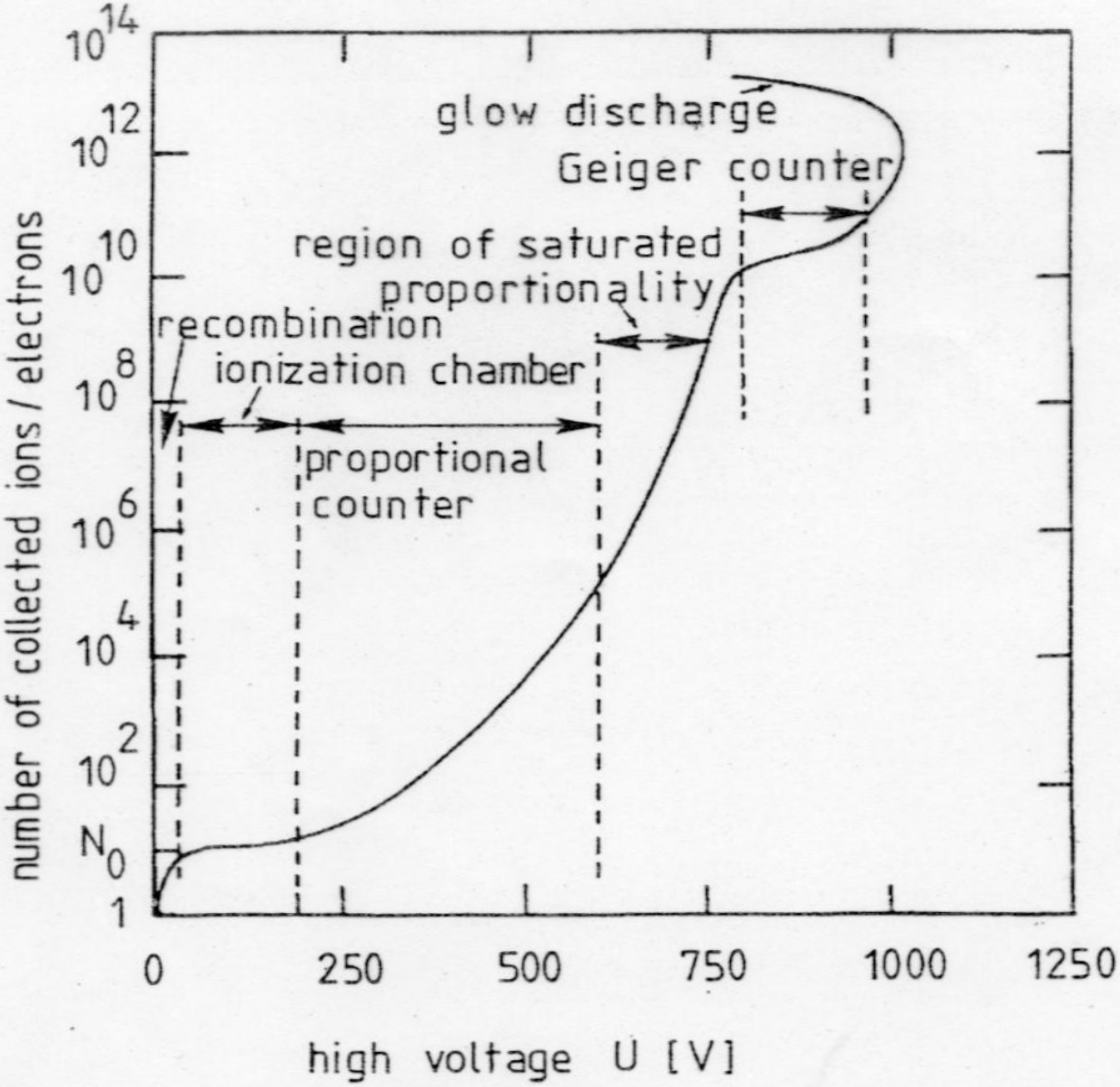


Fig. 4.21. Characterization of the modes of operation of cylindrical gas detectors (after [51]).

Ionisationskammer

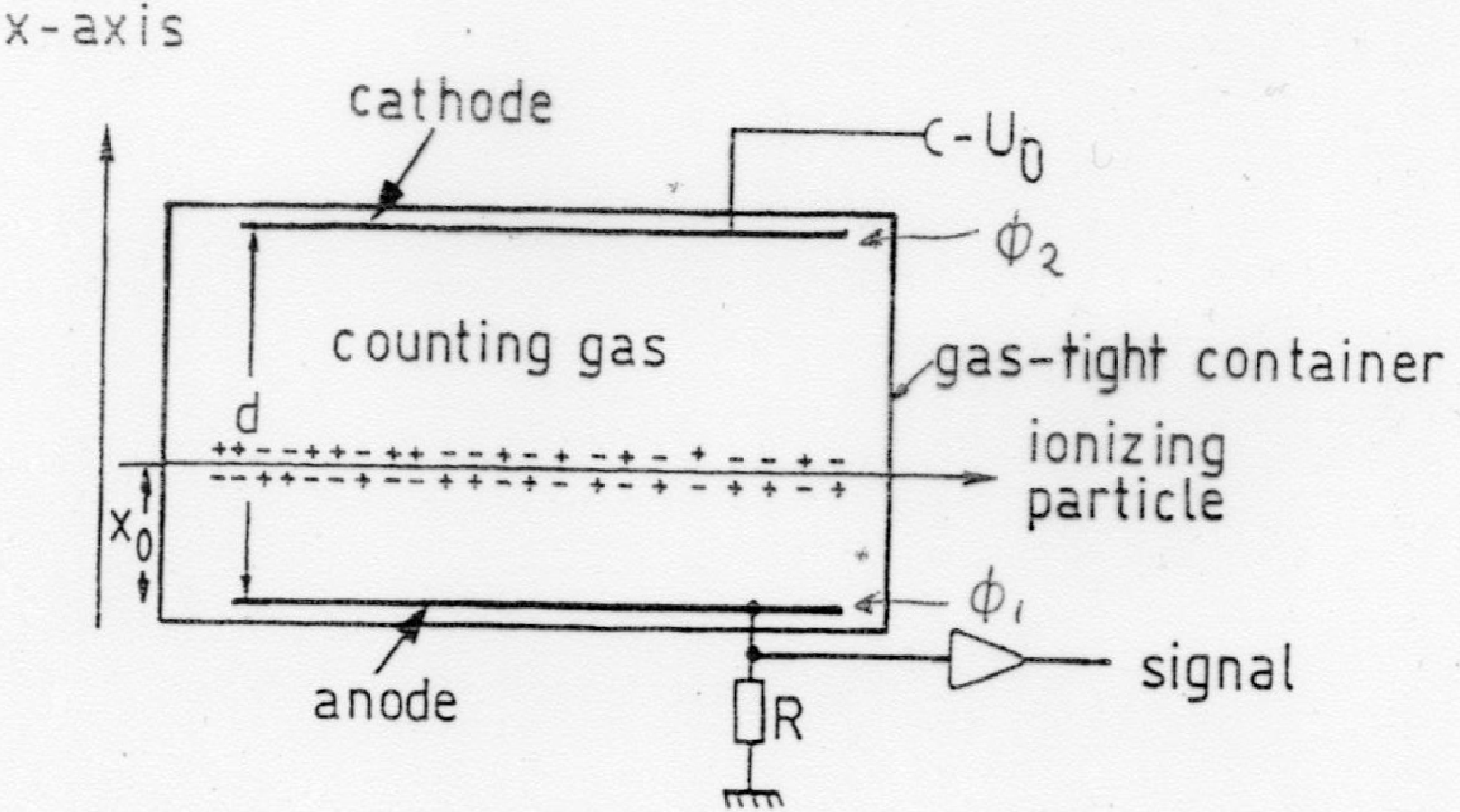


Fig. 4.1. Principle of operation of a planar ionization chamber.

Gasverstärkung in der Nähe eines Anodendrahtes:

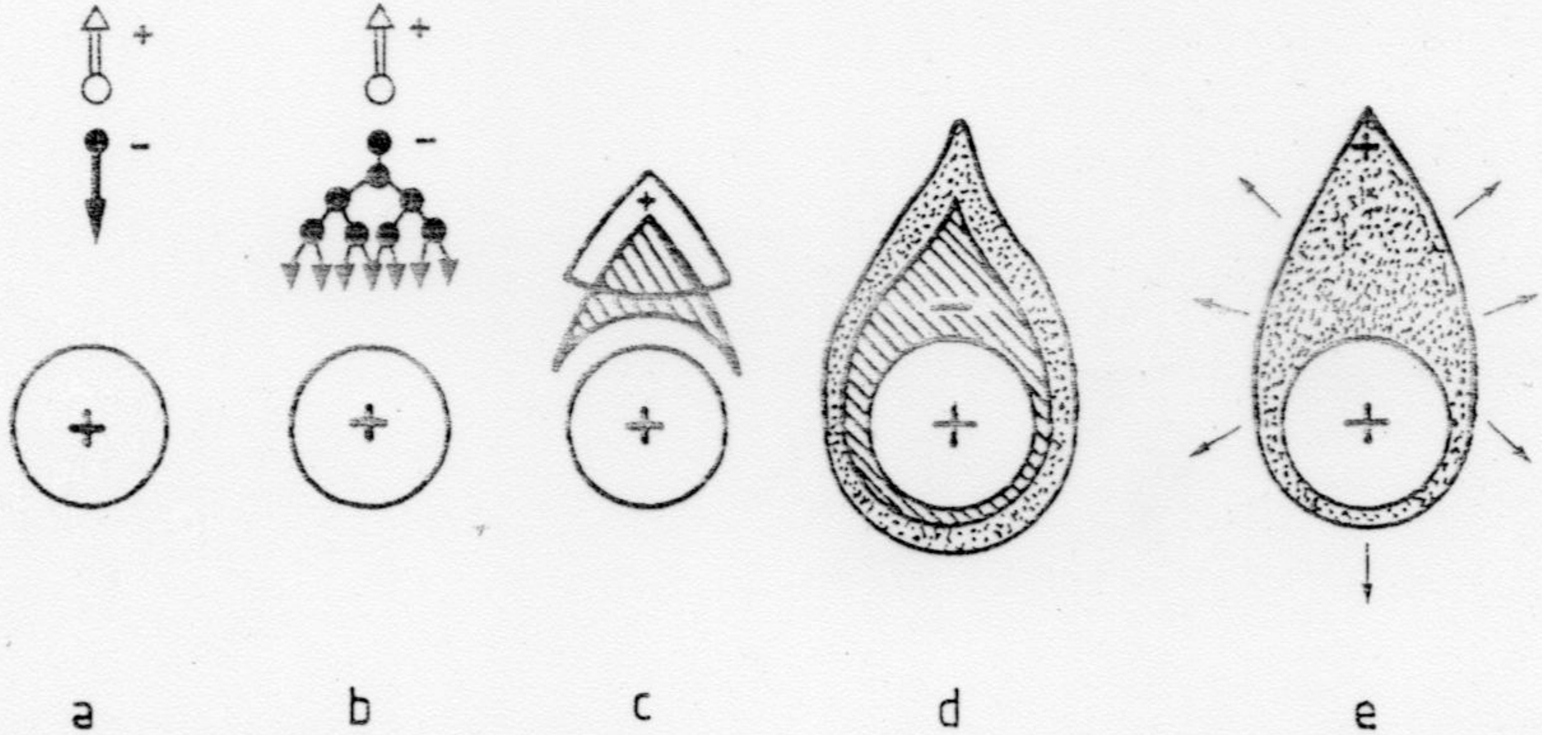


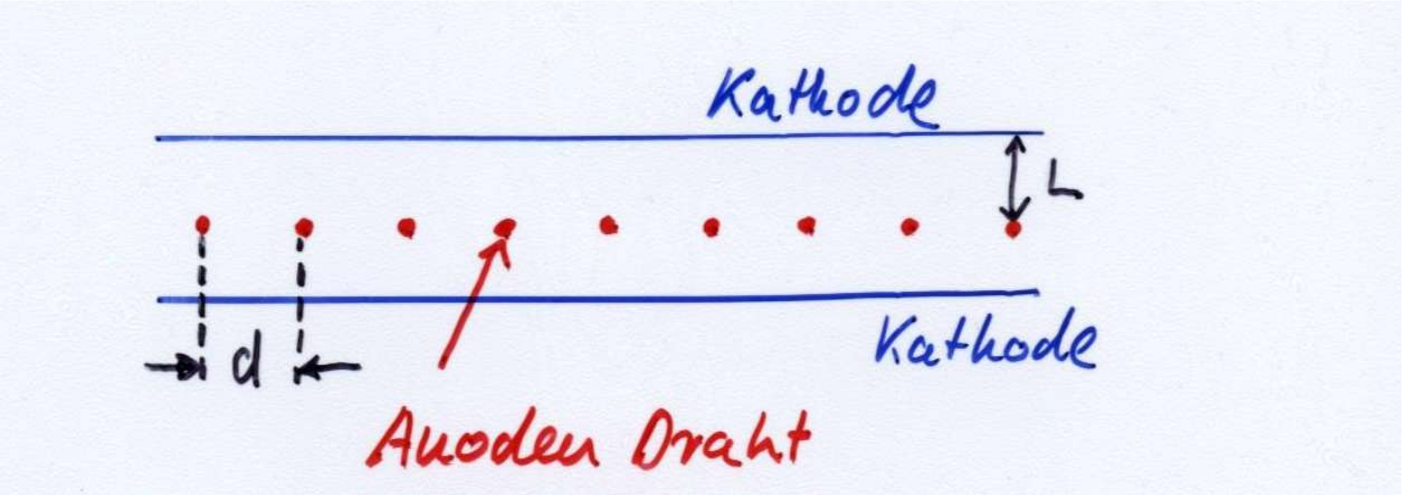
Fig. 4.27. Temporal and spatial development of an electron avalanche [51, 186].

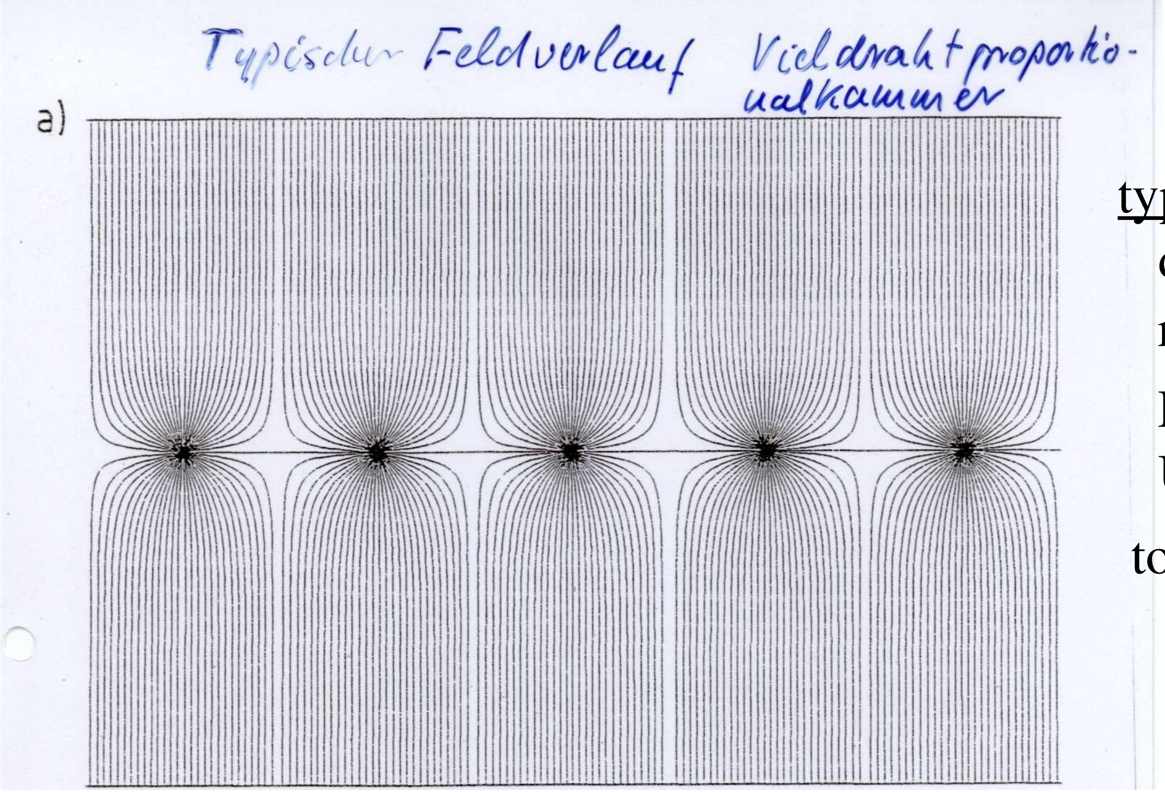
Elektronen der Lawine erzeugen sehr schnelles und kleines Signal
(kurze Driftstrecke)
induziertes Signal hauptsächlich durch langsame Ionendrift

Vieldrahtproportionalkammer

G. Charpak et al. NIM 62 (1968) 202   Nobelpreis 1992, Rev. Mod. Phys. 65 (1993) 591

planare Anordnung von
vielen Proportionalzählern
ohne Trennwände




Typischer Feldverlauf Vieldrahtproportionalkammer

typische Parameter:

$d = 2 – 4$ mm

$r_i = 20 – 25$ µm

$L = 3 – 6$ mm

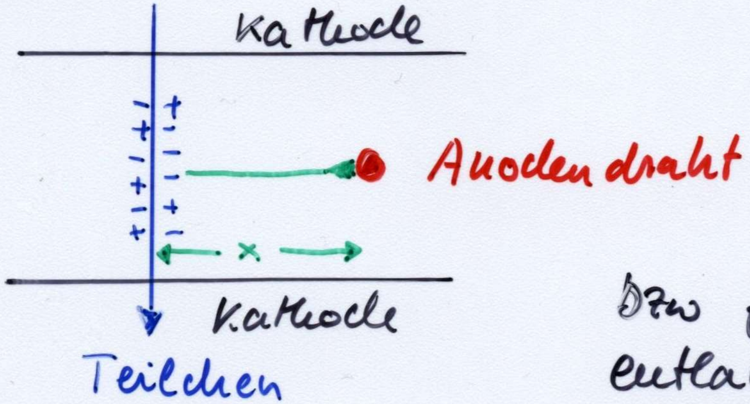
U_0 = several kV

totale Fläche: m^2

Driftkammer

A. Walenta, J. Heintze 1970 Phys. Inst. Univ. Heidelberg (NIM <u>92</u> (1971) 373)

<u>Prinzip</u> :



Zeitmessung

$$x = v_D^- \cdot \boxed{\Delta t}$$

Driftgeschwindigkeit

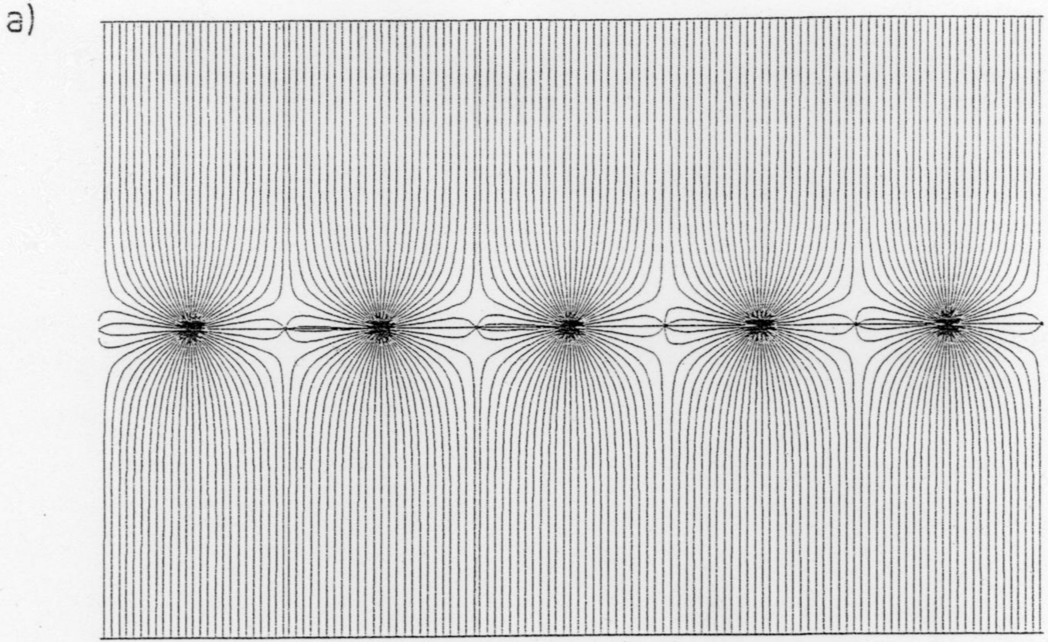
bzw falls sich Driftgeschw. entlang des Weges ändert

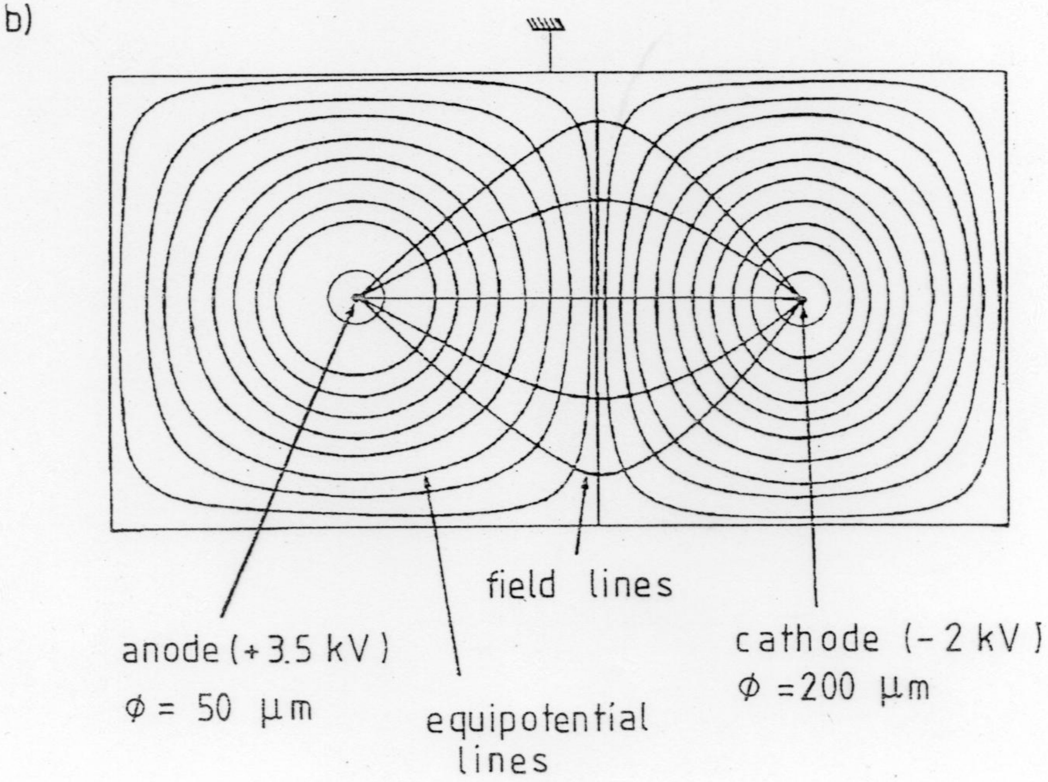
$$x = \int v_D^-(t)\,dt$$

in MWPC zwischen Anoden-Drähten
Regionen mit sehr niedrigem E-Feld

Einführung zusätzlicher Felddrähte
mit negativem Potential verbessert
Feldqualität dramatisch

essentiell für Driftkammer in der
Ortsauflösung bestimmt durch
Driftzeitvariationen und nicht durch
Struktur der segmentierten Elektrode





Zylindrische Kammern im Magnetfeld betrieben → Messung des Krümmungsradius einer Teilchenspur → Impulsmessung (innerhalb eines einzigen Detektors)

$$p\,(\mathrm{GeV}/c) = 0.3 \cdot B\,(\mathrm{T}) \cdot \rho\,(\mathrm{m})$$

Prinpip einer zylindrischen Driftkammer: Drähte in axiale Richtung (parallel zu kollidierenden Teilchen und dem Magnetfeld)

alternierende Anoden- u
Felddrähte

- je ein Felddraht zwisch
  2 Anodendrähten
- zylindrische Lagen vo
  Felddrähten zwischen
  Lagen von
  Anodendrähten

-> gut geformte
Driftzellen