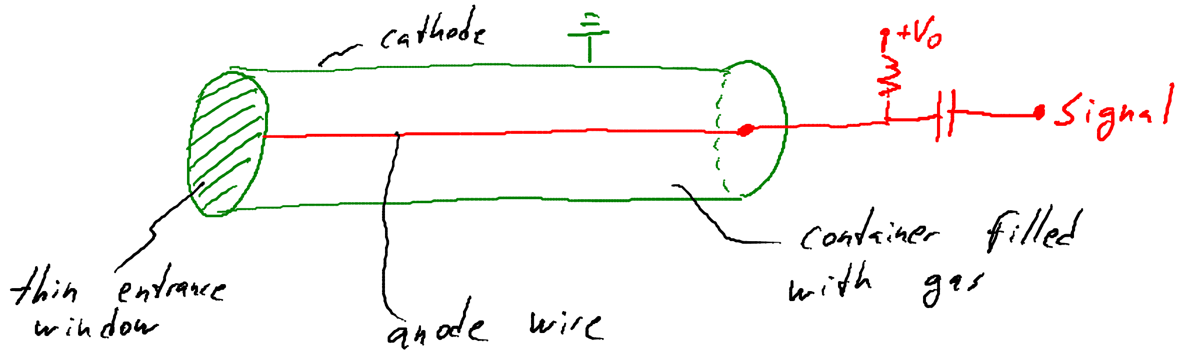
# 3 Ionization detectors

Direct collection of electron/ions produced by the passage of radiation through a gas (or liquid).




- Radial electric field $E = \frac{1}{r} \cdot \frac{V_0}{\ln(b/a)}$

  ( a ≙ radius anode wire
  b ≙ inner radius of cylinder )

- $e^-$ move towards anode (typical ~ $10^5$ m/s = 100 μm/ns)

  ions move towards cathode (typical 1-10 m/s = $10^{-3}$ - $10^{-2}$ μm/ns)

- Charge collected before recombination depends on applied voltage

(I) More and more of original $e^-$-ion-pairs are collected before they recombine

(II) All pairs are collected

→ IONIZATION CHAMBER

(very small signal)

(III) Electrons are accelerated so much that

(III) Electrons are accelerated so much that they can ionize gas molecules → avalanche or cascade effect.
Number of $e^-$ in avalanche is proportional to number of original $e^-$-ion-pairs.

→ PROPORTIONAL COUNTER

(avalanches mainly close to anode wire where field is strongest)

(IIIb) Space charge effects distorts field around anode → proportionality gets lost

(IV) Gas discharge → always same amplitude → GEIGER-MÜLLER COUNTER

(Quenching gas absorbs photon and stops process)

(V) Detector can be damaged

## 3.1 Ionization and transport mechanism

Excitation of atom: $X + p \to X^* + p$
(further reactions can lead to ionization)

Ionization: $X + p \to X^+ + e^- + p$

- How much energy is needed in average to create one ion-electron-pair? (including losses)

| | W (in eV/pair) for fast $e^-$ | W (in eV/pair) for $\alpha$ |
|---|---|---|
| He | 41,3 | 42,7 |
| $N_2$ | 34,8 | 36,4 |
| $O_2$ | 30,8 | 32,2 |
| Ar | — | 26,3 |
| Xe | — | 22 |

$\hat{=}$ always $\sim 30\ eV/pair$

(e.g. 1 MeV $\alpha$ $\hat{=}$ A $\approx 3 \times 10^4$ pairs)

typical Fano factors around 0,25

($\hat{=}$ A = 30.000 $\pm$ 80 pairs)