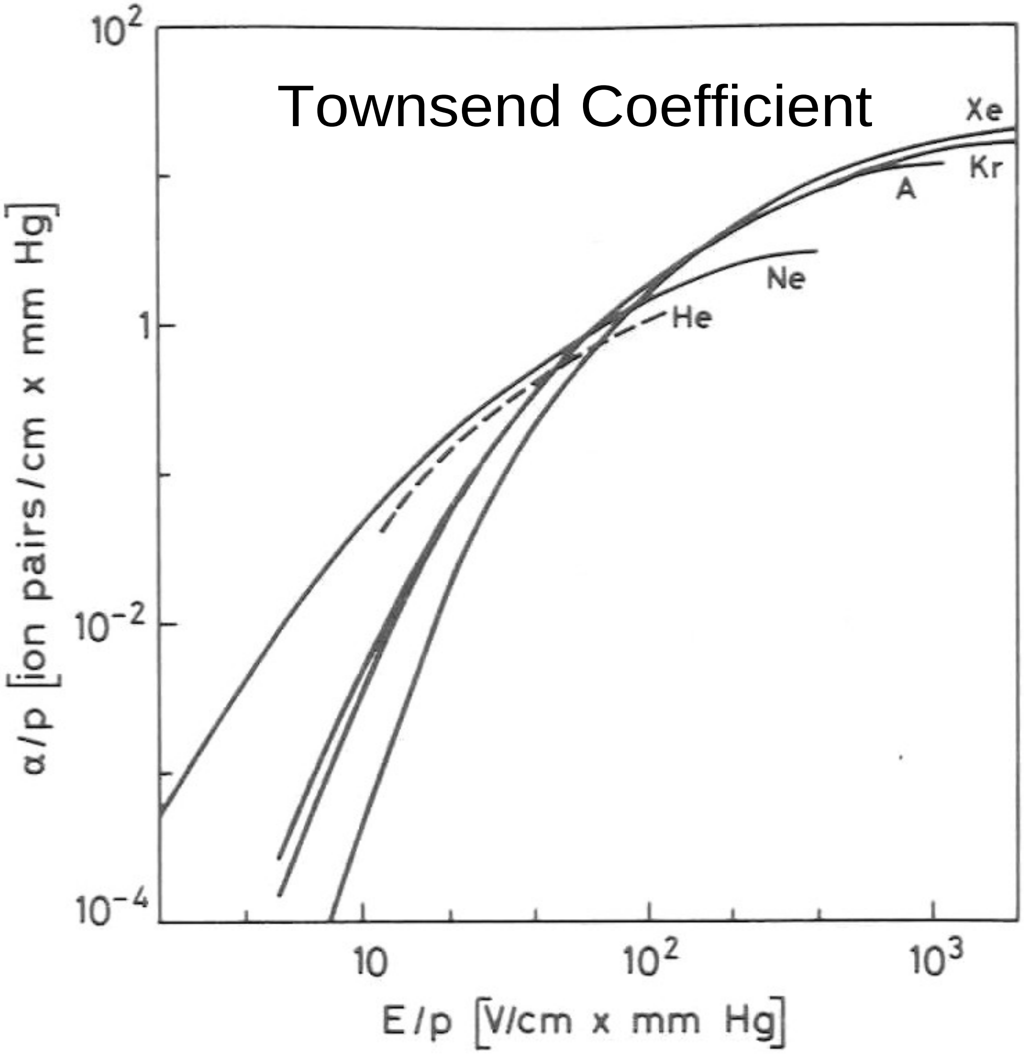
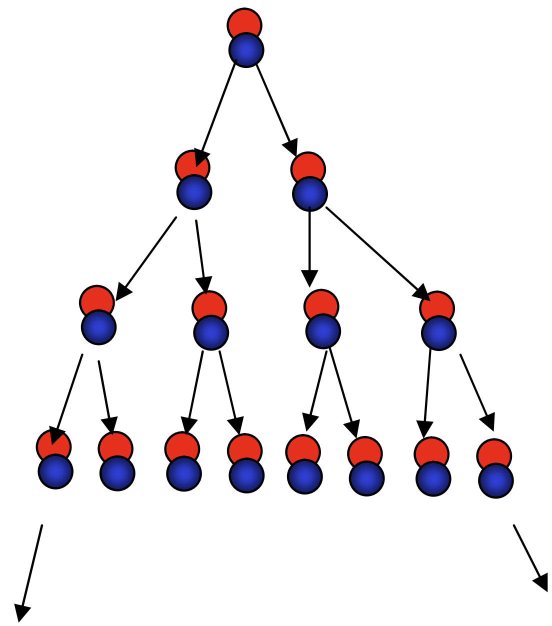
Avalanche Formation



Electron-ion pairs through gas ionization



$$dn = \alpha \cdot n \cdot dx$$

$$n(x) = n_0 \cdot e^{\alpha \cdot x} \quad for \;\; \alpha = const$$

$$n(x) = n_0 \cdot \exp\left\{ \int_0^x \alpha(x')dx' \right\}$$

Electrons in outer shells are more readily removed from atom. Ionization energies are smaller for heavier elements.

Effective Ionization Energies

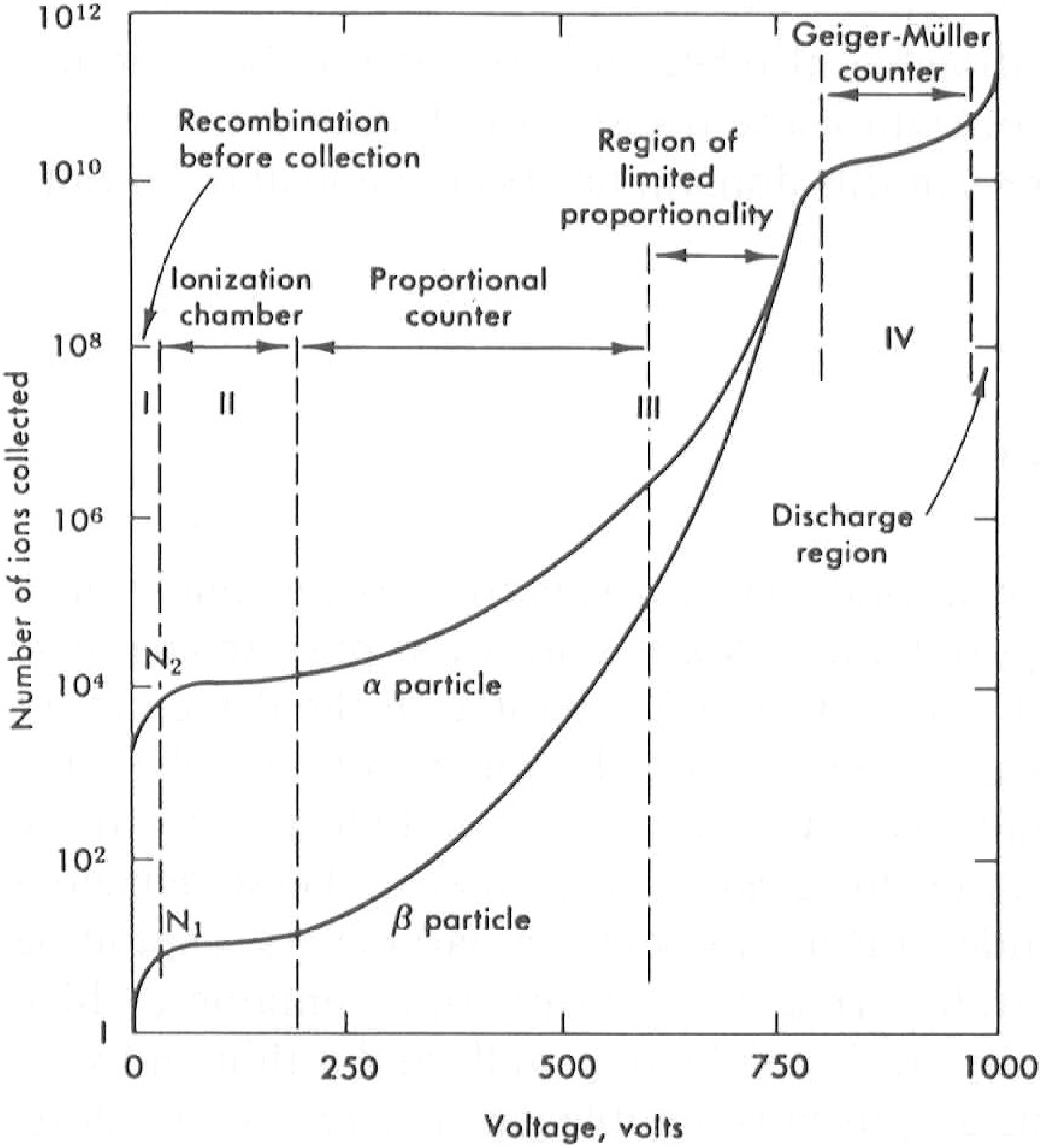
Excitation and ionization characteristics of various gases

	Excitation potential [eV]	Ionization potential [eV]	Mean energy for ion-electron pair creation [eV]
H_2	10.8	15.4	37
He	19.8	24.6	41
N_2	8.1	15.5	35
O_2	7.9	12.2	31
Ne	16.6	21.6	36
Ar	11.6	15.8	26
Kr	10.0	14.0	24
Xe	8.4	12.1	22
CO_2	10.0	13.7	33
CH_4		13.1	28
C_4H_{10}		10.8	23

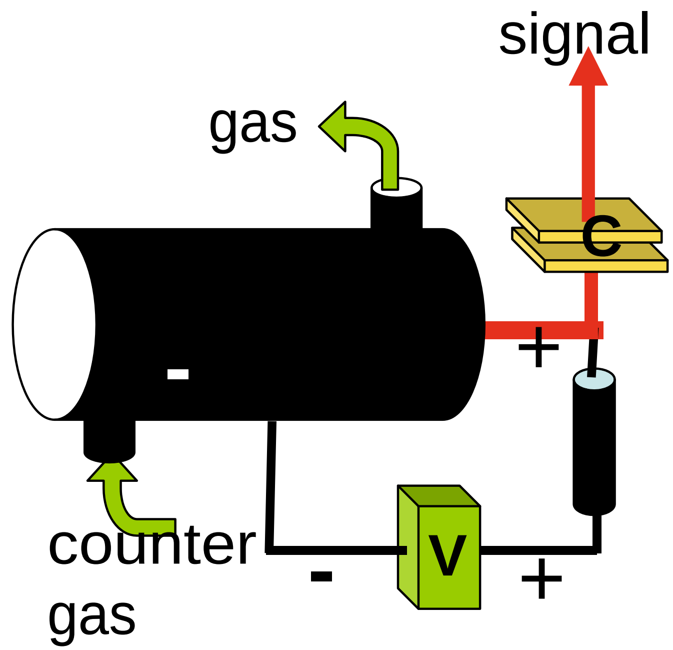
Mean energy per ion pair larger than IP because of excitations

Large organic molecules have low-lying excited rotational states → excitation without ionization through collisions → quenching additives

Amplification Counters

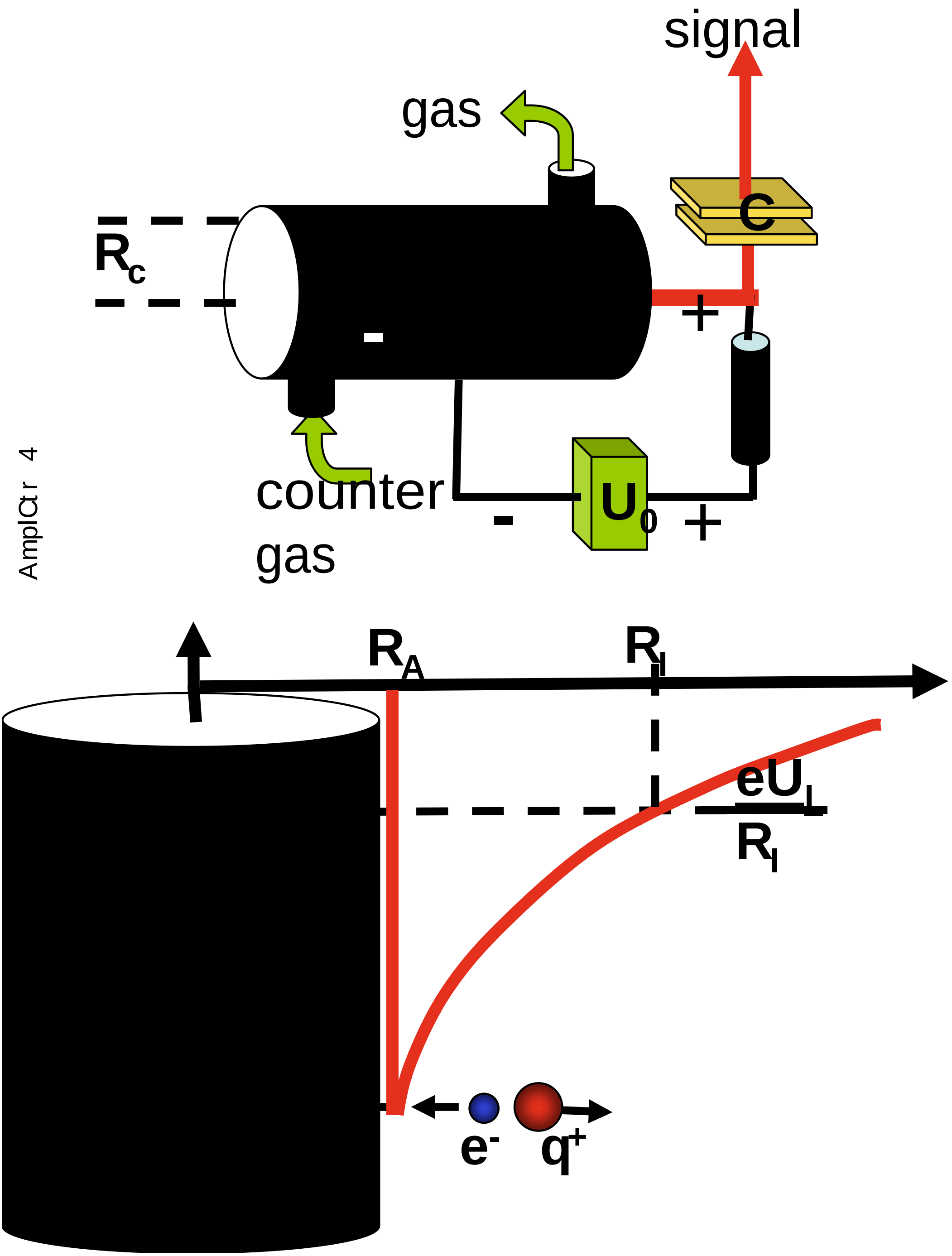


Single-wire gas counter



W. Udo Schröder

Proportional Counter



Anode wire: small radius $R_A \approx 50\ \mu m$ or less

Voltage $U_0 \approx (300\text{-}500)$ V

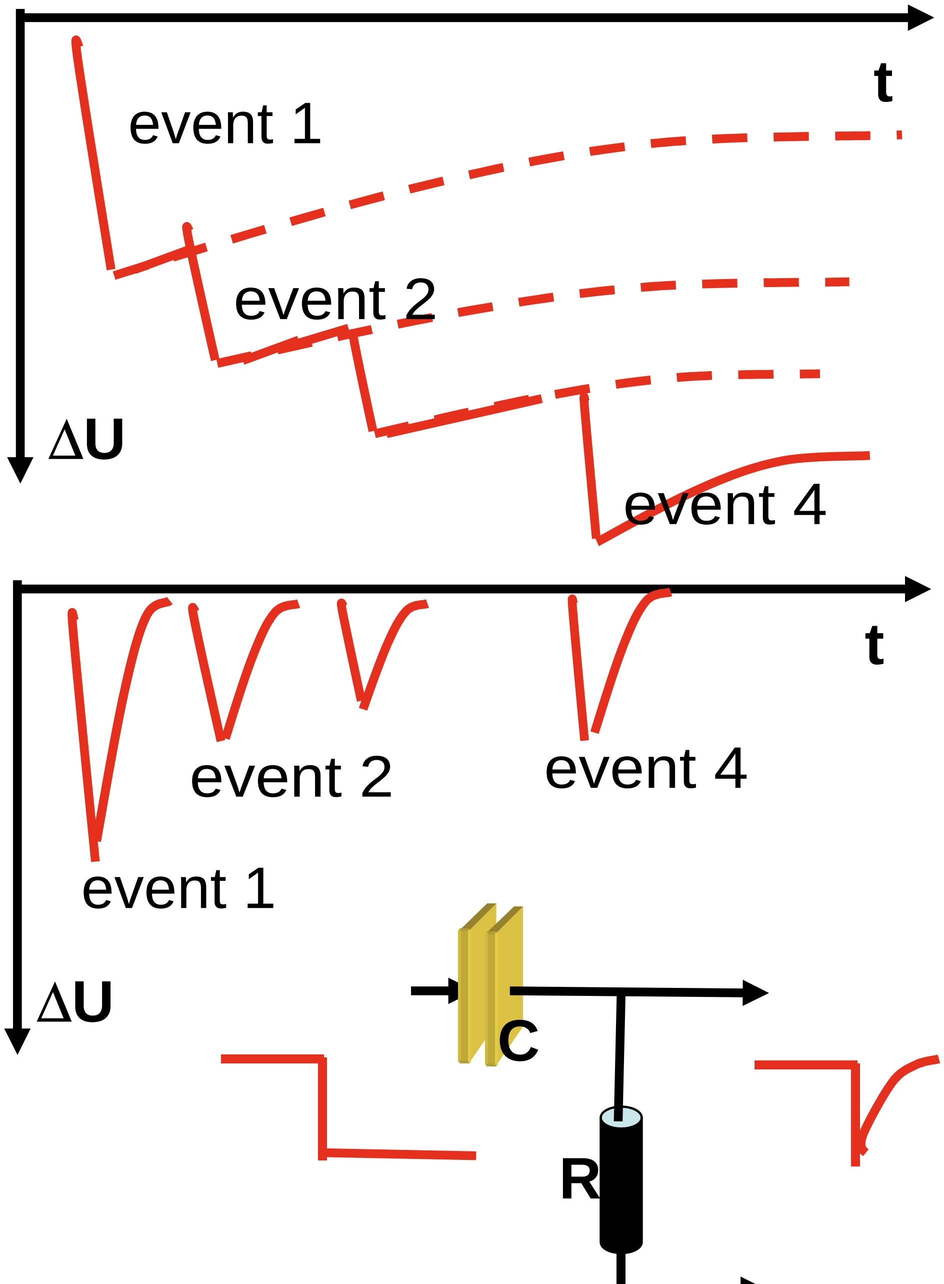
Field at r from wire

$$E(r) = \frac{U_0}{\ln(R_C/R_A)} \cdot \frac{1}{r}$$

Avalanche $R_I \rightarrow R_A$, several mean free paths needed

Pulse height mainly due to positive ions (q^+)

Pulse Shape



$$Pulse\ shape: time\ t,\ \ wire\ length\ L$$

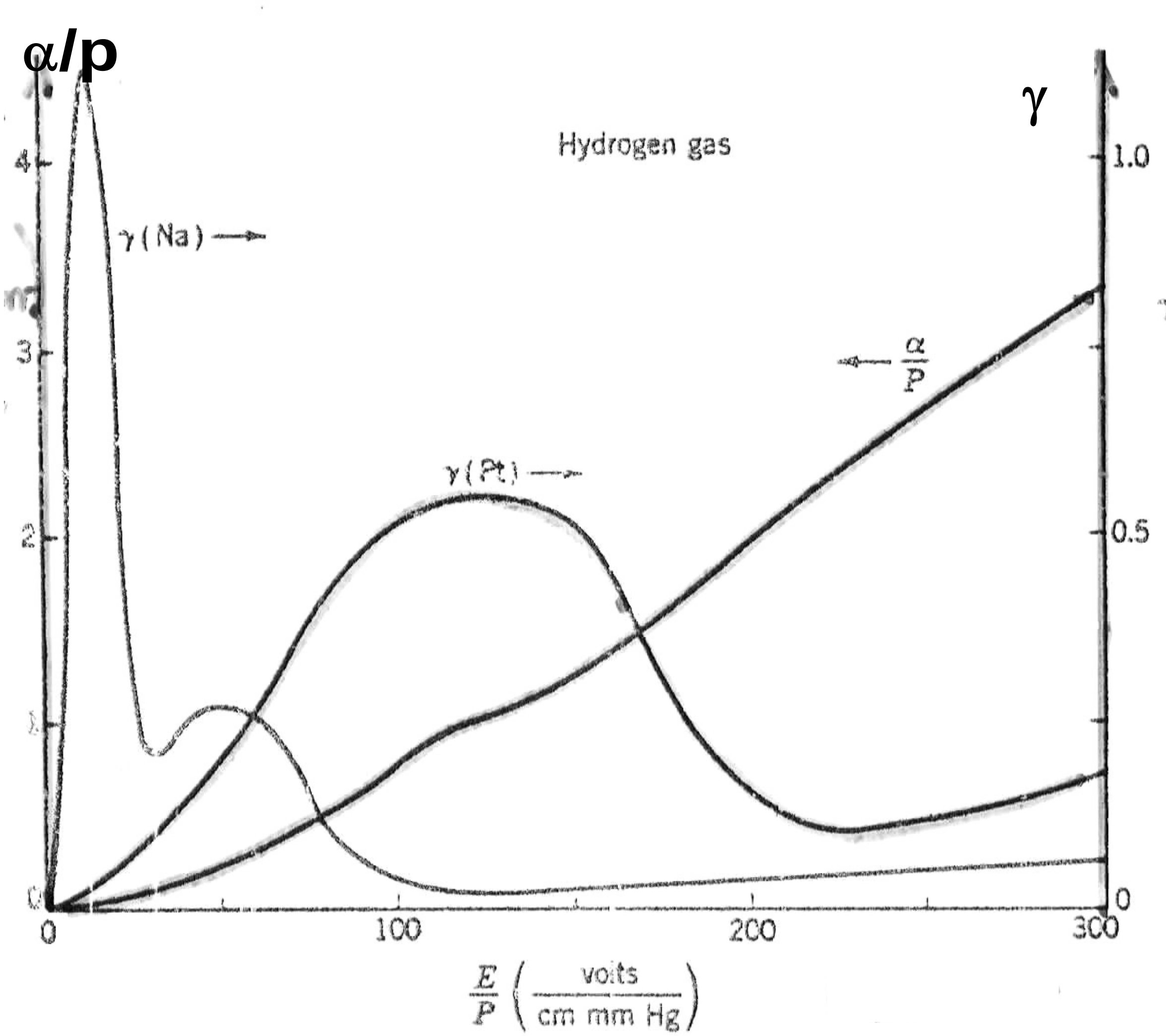
$$\Delta U(t) \propto \frac{-q}{4\pi\varepsilon L} \cdot \ln(1 - \frac{t}{t_0})$$

$$t_0 = \pi\varepsilon / \mu C U_0,\ \ mobility\ \ \mu = u_{drift} / E$$

long decay time of pulse → pulse pile up, summary information

differentiate electronically, RC-circuitry in shaping amplifier, individual information for each event (= incoming particle)

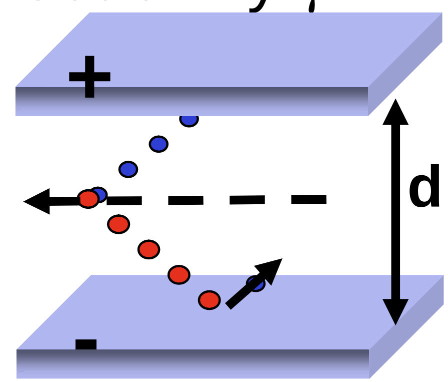
Sparking and Spark Counters



Prevent spark by reducing λ for ions: collisions with large organic molecules
→ **quenching**

Impact ionization

Probability γ



Amplification by impact ionization

$$M = \frac{n}{n_0} = \frac{e^{\alpha \cdot d}}{1 - \gamma \cdot \left[e^{\alpha \cdot d} - 1 \right]}$$

$$\text{Sparking}: \gamma \cdot e^{\alpha \cdot d} \approx 1$$

$$p \sim (10^{-1} - 10^{-3})\, Torr$$