Correlation between t.o.t. and base voltage

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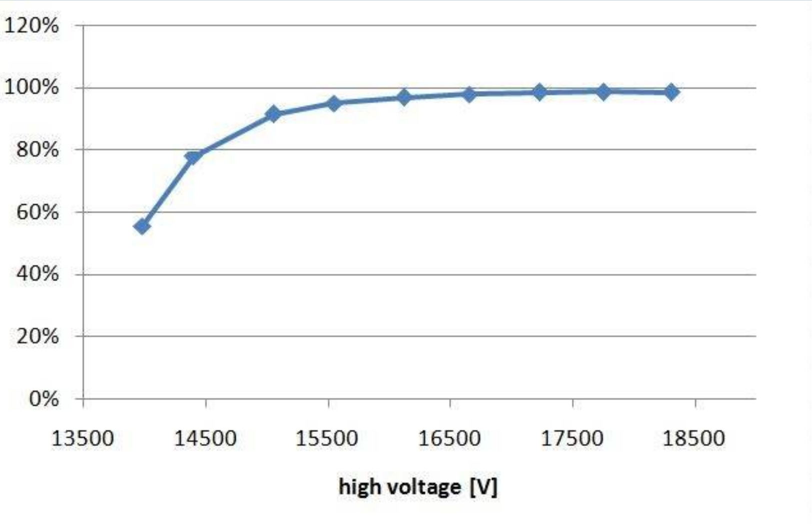
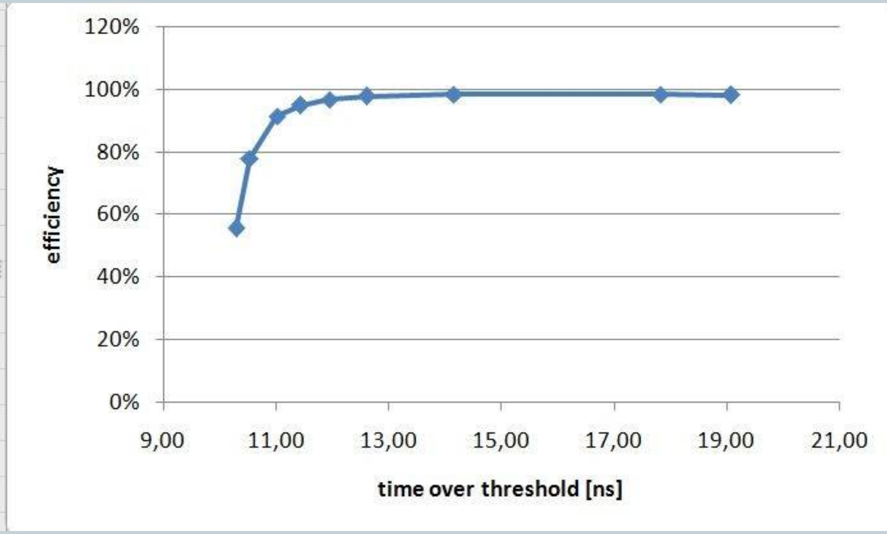
Introduction

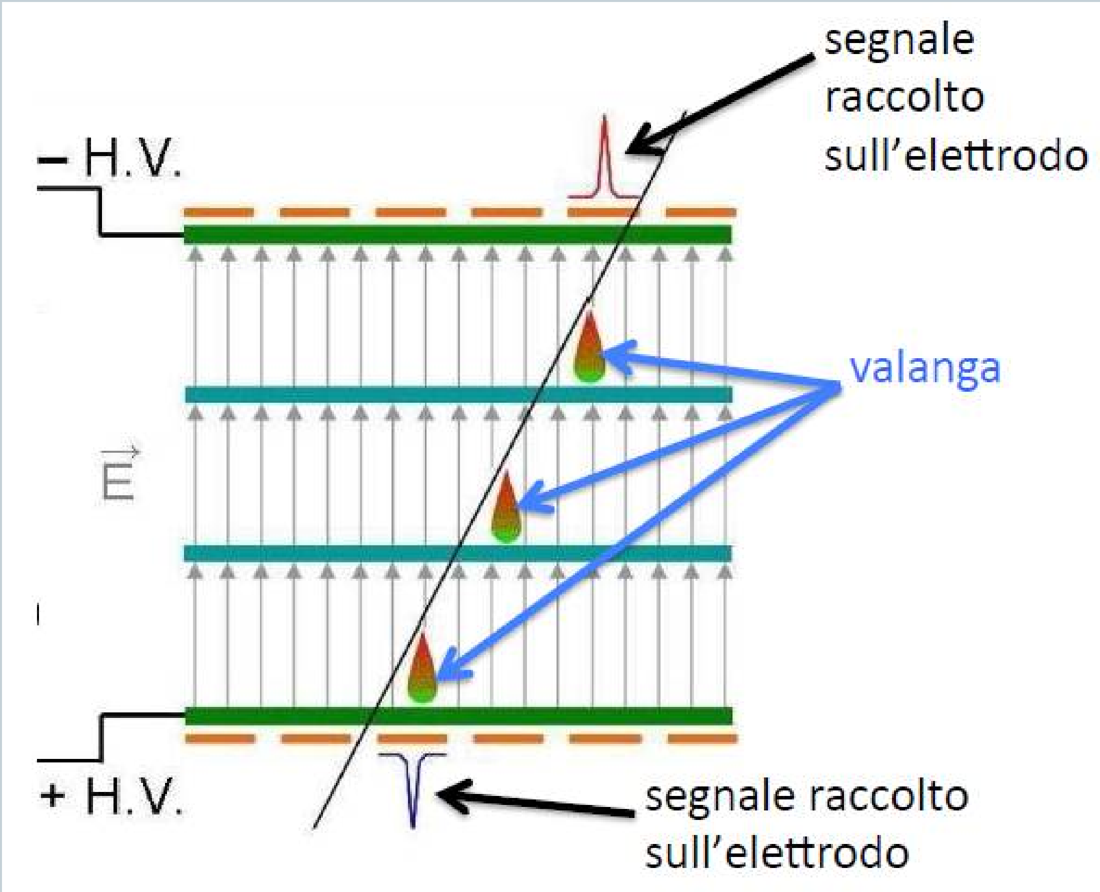
Fig. 1





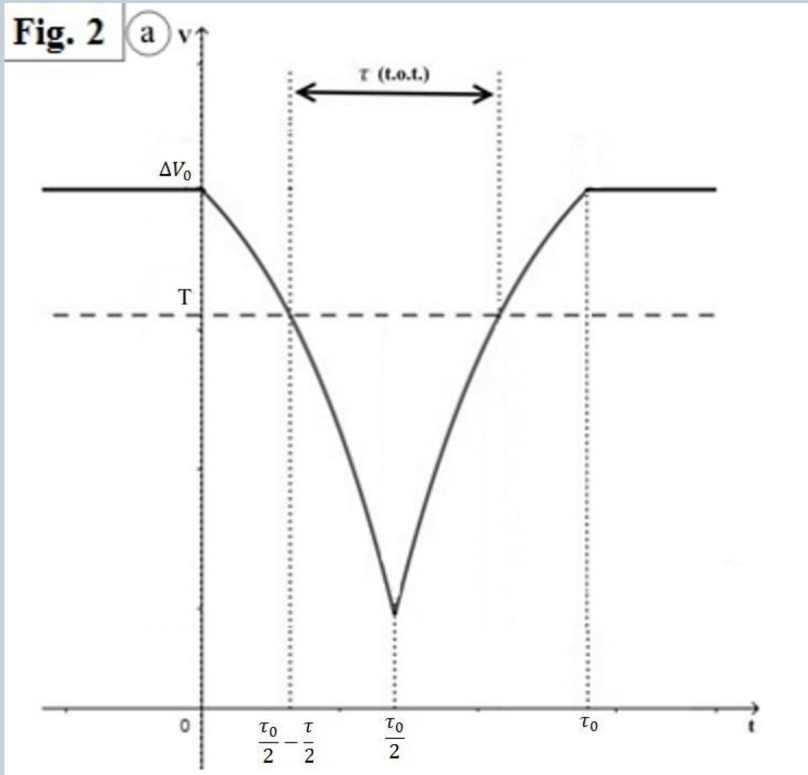
The efficiency tends towards 98% while the t.o.t. grows, as it does with the high voltage.

The signal


segnale
raccolto
sull'elettrodo
– H.V.
valanga
E
+ H.V.
segnale raccolto
sull'elettrodo

Time over threshold

- Not all the signals are recorded, only those whose variation in the voltage goes beyond a threshold (350mV).
- **Time over threshold (t.o.t.)**: interval that the signal passes beyond the threshold.



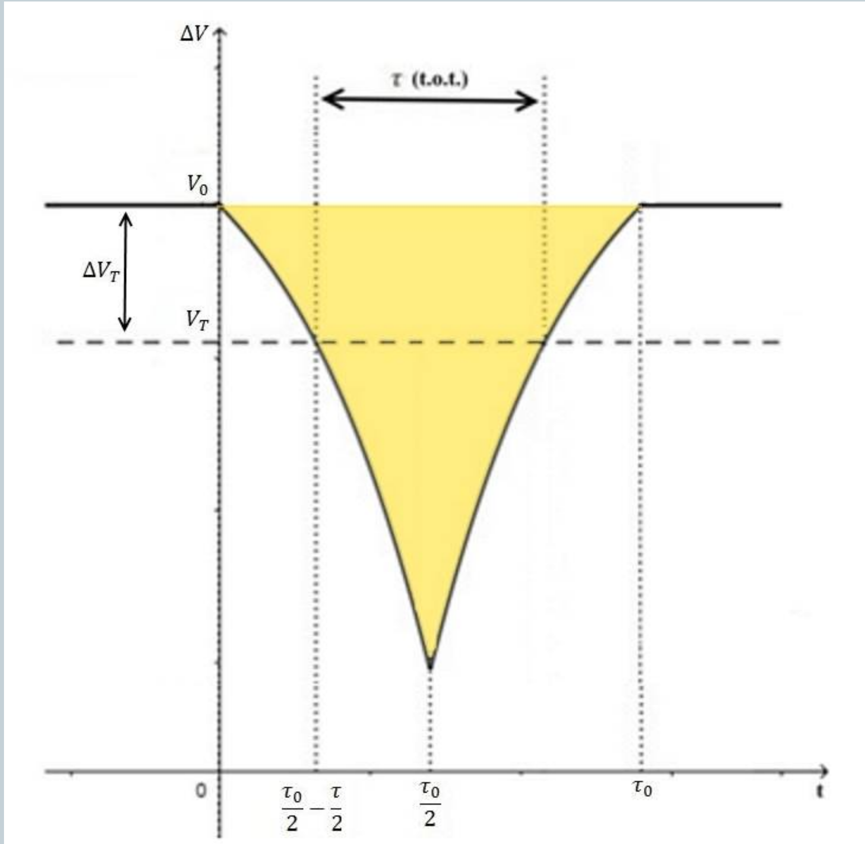
Collected charge as a function of time

$$V(t) = R\frac{dQ(t)}{dt}$$

$$V(t) = \frac{l}{\varepsilon S}Q(t)$$

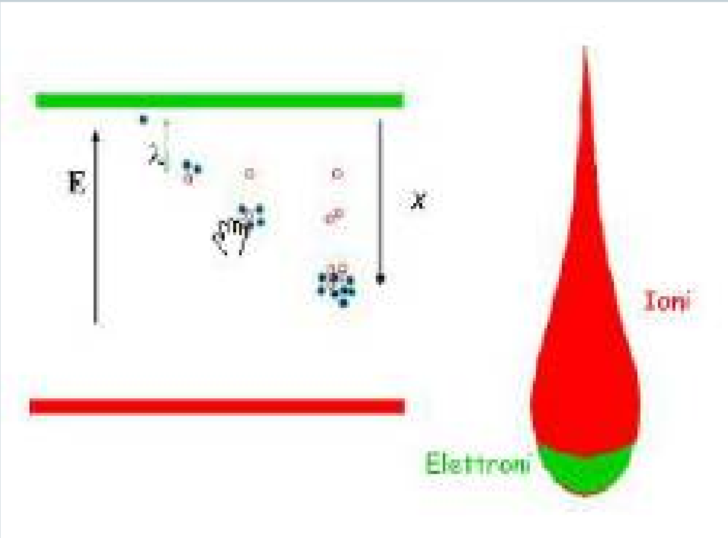
$$Q(t) = Q_0(1 - e^{\frac{l}{\varepsilon S R}t})$$

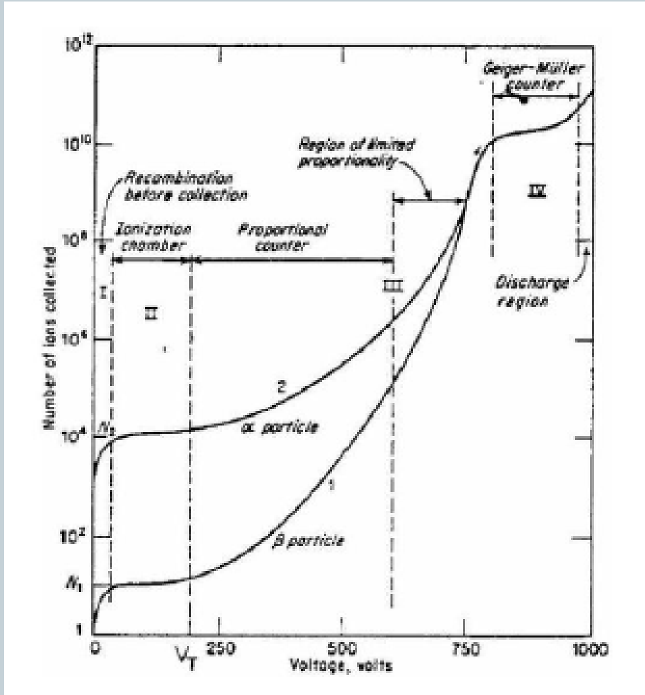
$$\Delta V(t) = V_0\left(1 - e^{\frac{l}{\varepsilon S R}t}\right)$$



The ionization

The electric field separates electrons and positive ions





The collected charge also depends on the gas and on the intensity of the electric field; our detector operates in the proportional counter.

The total collected charge

- Total number of collected electrons or ions:

$$N = N_0 e^{(\alpha - \eta) l}$$

- The Townsend coefficient α depends on the electric field $E=V_0/l$, so the equation becomes:

$$N = N_0 e^{[\alpha(V_0) - \eta(V_0)] l}$$

- The total collected charge equals that number times the elementary charge an is reached at $\tau_0/2$, where $\tau_0$is the total time of the signal:

$$Q_{tot} = Q_0 - Q\left(\frac{\tau_0}{2}\right) = Q_0 e^{\frac{l}{2\varepsilon SR}\tau_0} = q_e N_0 e^{[\alpha(V_0) - \eta(V_0)] l}$$

T.o.t. as a function of low voltage

- the low voltage reaches the threshold at $t = \frac{\tau_0}{2} - \frac{\tau}{2}$:

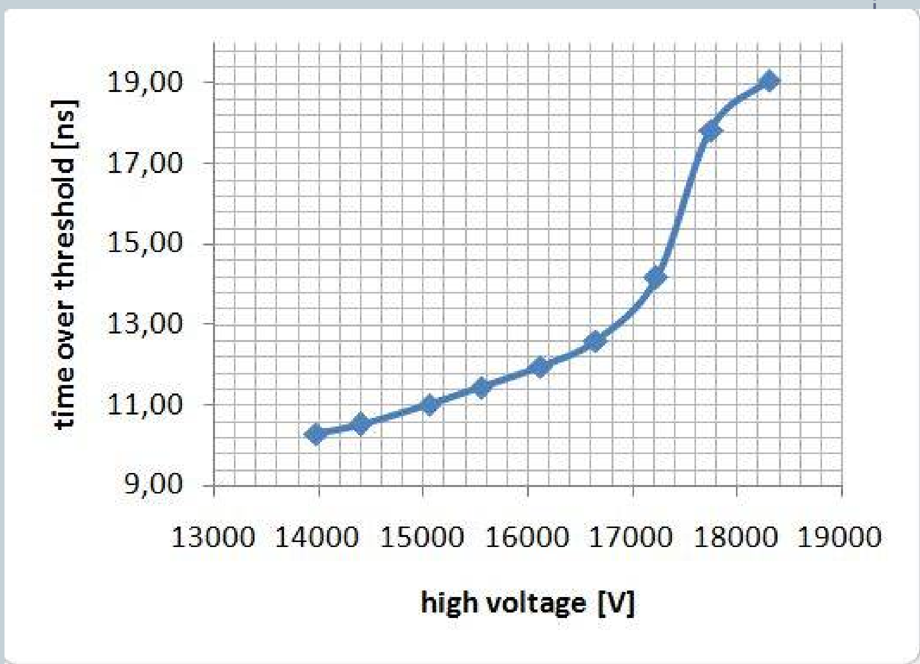
$$V_T = \frac{l}{\varepsilon S} Q\left(\frac{\tau_0}{2} - \frac{\tau}{2}\right) = V_0 - \frac{l}{\varepsilon S} Q_0 \frac{e^{\frac{l}{2\varepsilon SR}\tau_0}}{e^{\frac{l}{2\varepsilon SR}\tau}} = -\frac{l}{\varepsilon S} Q_{tot} e^{-\frac{l}{2\varepsilon SR}\tau} + V_0$$

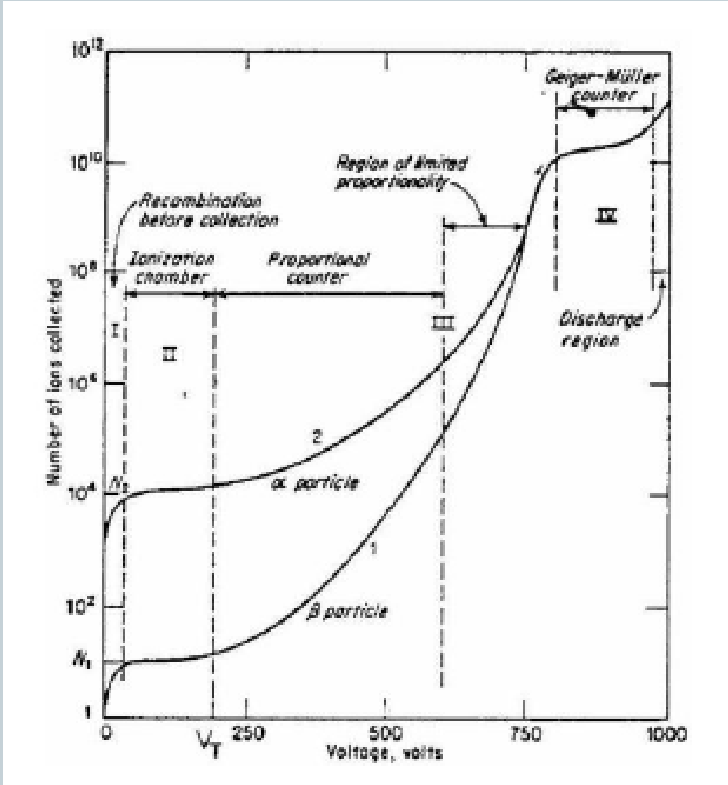
- Therefore the t.o.t. is:

$$\tau(V_0) = 2\varepsilon SR[\alpha(V_0) - \eta(V_0)] - \frac{2\varepsilon SR}{l} \ln \frac{\Delta V_T}{\frac{l}{\varepsilon S} q_e N_0}$$

where the threshold $\Delta V_T = V_0 - V_T$ is fixed

Results





In the proportional counter region the function that describes the gas coefficients is similar to the t.o.t. function obtained from experimental data.

Discussion

- The difference between the base voltage and the threshold being always the same, the t.o.t. increases with the area of the signal 'triangle', because the charge collected during the avalanche increases with the intensity of the electric field.
- The efficiency is correlated to the high voltage, and so it is for the t.o.t.. And we believe that is the reason why the the efficency versus t.o.t. has the same slope of the high voltage.

References

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