Simulation of MCP-PMT

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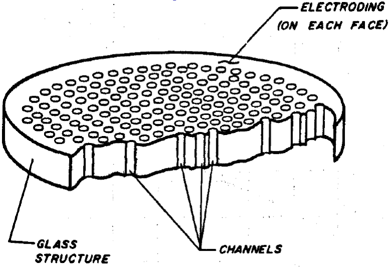
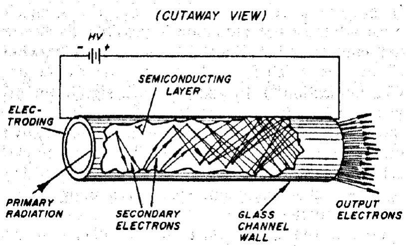
27. 9. 2022

Microchannel plates





Model of ideal gain

$$\delta = KV_c$$

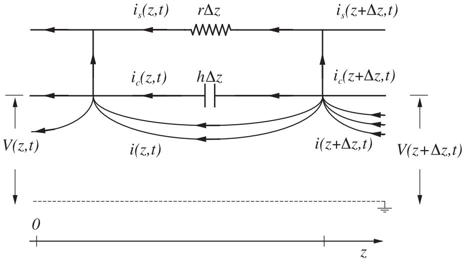
$$G = \delta^n = \left(\frac{KV_0}{4V\alpha^2}\right)^{\frac{4V\alpha^2}{V_0}}$$

Too simple: does not take into account emission angles, fringe fields, charge distribution, etc.

Original pictures from: Wiza, J. L. (1979). Microchannel plate detectors. Nucl. Instrum. Methods, 162(1-3), 587-601.

Transmission line model

- We consider TLM by L. Giudicotti
- In this model a channel is divided into parts represented by lumped component
- Kirshoff's laws are then used to derive the model equations
- Assumption: input pulse is shorter than typical charge recovery time RC, but longer than the average transit time



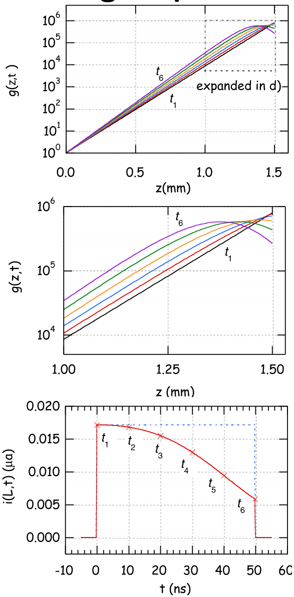
Original paper: Giudicotti L. Nucl. Instrum. Methods Phys. Res. A, 659 (1) (2011), pp. 336-347

- We recalculated the derivation of the model equations
- Typo in (37): wrong sign in front of $(Q(x,t)/Qs)_n$

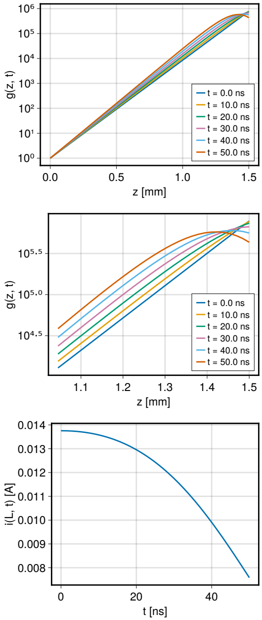
$$g(x,t) = \exp\left\{Gx + \int_0^x \ln\left(1 + e^{\frac{-t}{RC}}\frac{Q_{W0}(t) + Q_0(t) - Q(x',t)}{Q_s}\right)\mathrm{d}x'\right\}$$

Recreation of results

Original plots



Recreation



Problem with the assumption

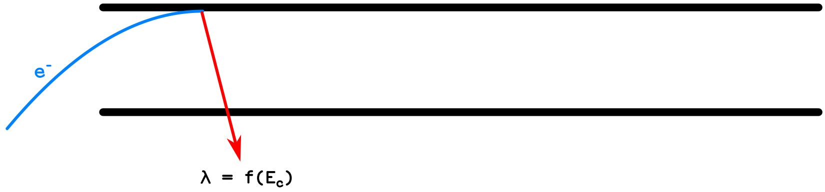
- The average number of photoelectrons arriving to MCP-PMT is between 15 and 45
- Typical number of microchannels is $10^6 - 10^7$
- This means that there is less than one photoelectron per channel and we can expect one photoelectron in a microchannel at maximum
- This corresponds to $i_0(t) = \delta(t) \Rightarrow$ signal length is shorter than transition time

Monte-Carlo simulation algorithm

1. Calculate trajectory and collision energy of an initial electron

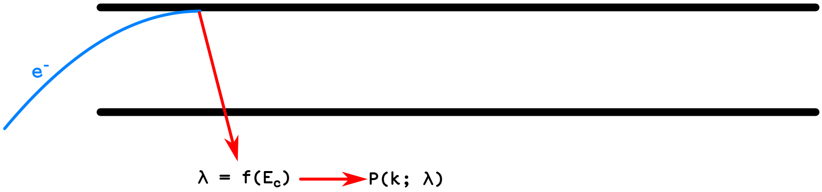
Monte-Carlo simulation algorithm

2. From the collision energy, calculate the number of secondary electrons using some secondary emission function



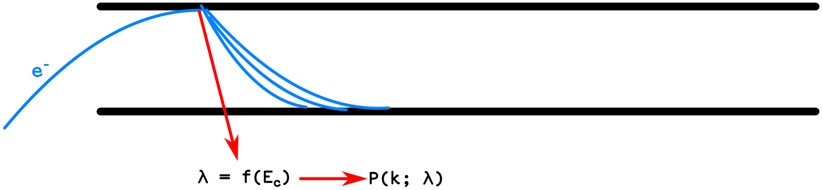
Monte-Carlo simulation algorithm

3. We use this value as the mean value of Poisson distribution and generate the random number of secondary electrons



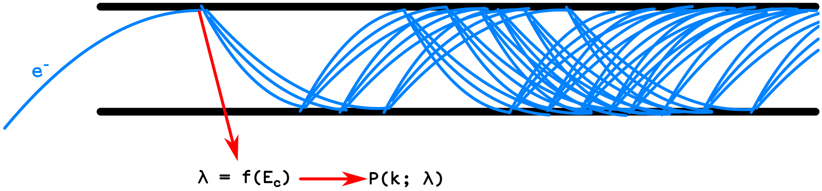
Monte-Carlo simulation algorithm

4. Assign random initial angles and energies to secondary electrons



Monte-Carlo simulation algorithm

5. Repeat for every secondary electron



Outlook

- Contact L. Giudicotti and discuss with him the problem of the assumption
- Improve the TLM simulation
- Work towards full Monte-Carlo simulation