Muons, Inc.

# Numerical simulation of the Micro-Channel Plates


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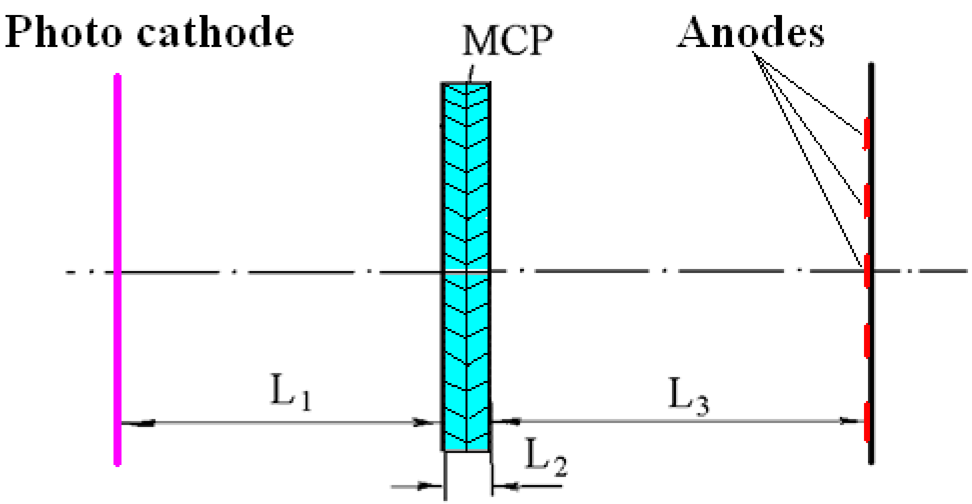
# Photo multiplier with the chevron-type micro channel plate

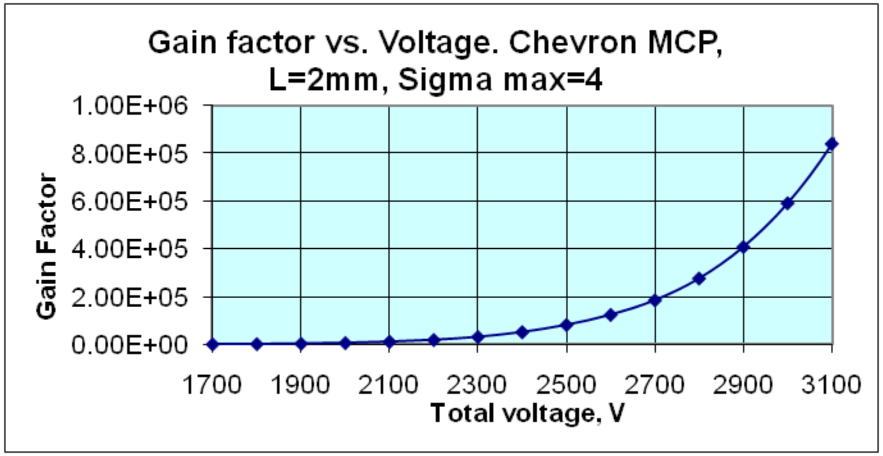


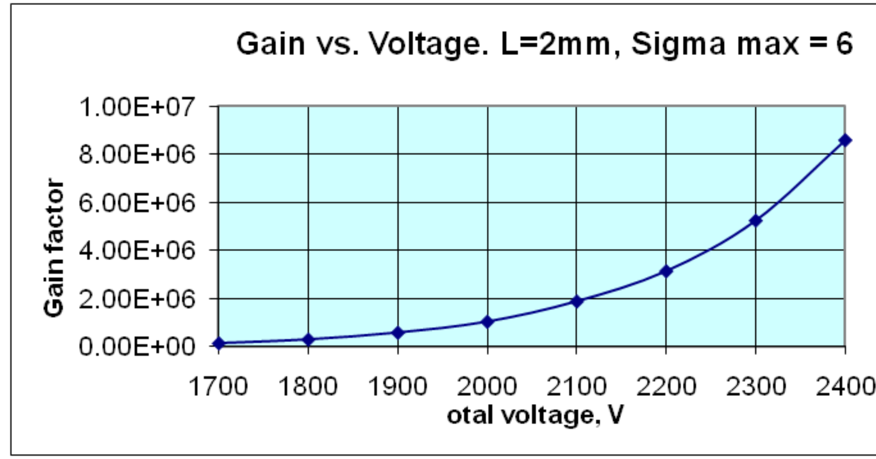

Schematic model of the photo multiplier 85022.

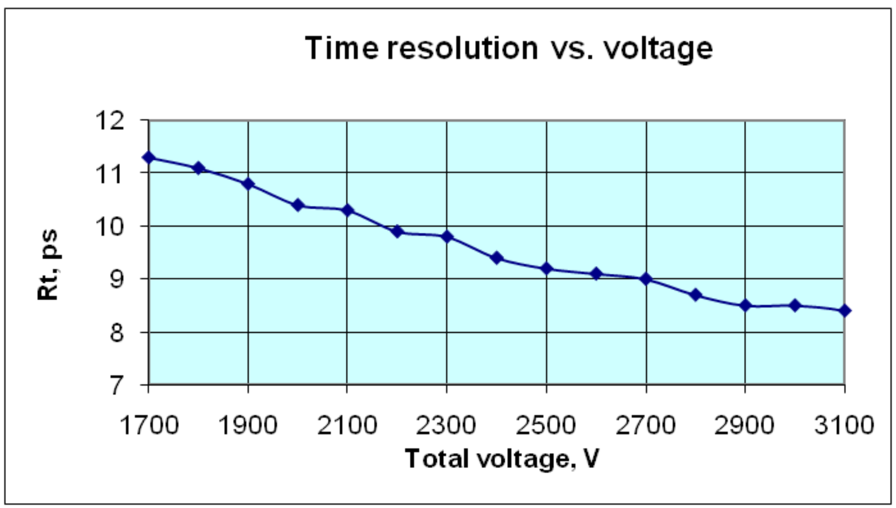
L1=4.4, L2=2, L3=3.7 mm. U1=0.091U, U2=0.82U, U3=0.09U, Where U – total voltage. The MCP is 2”x2” large, there are 1024 anodes, all equally spaced by 1.6 mm.

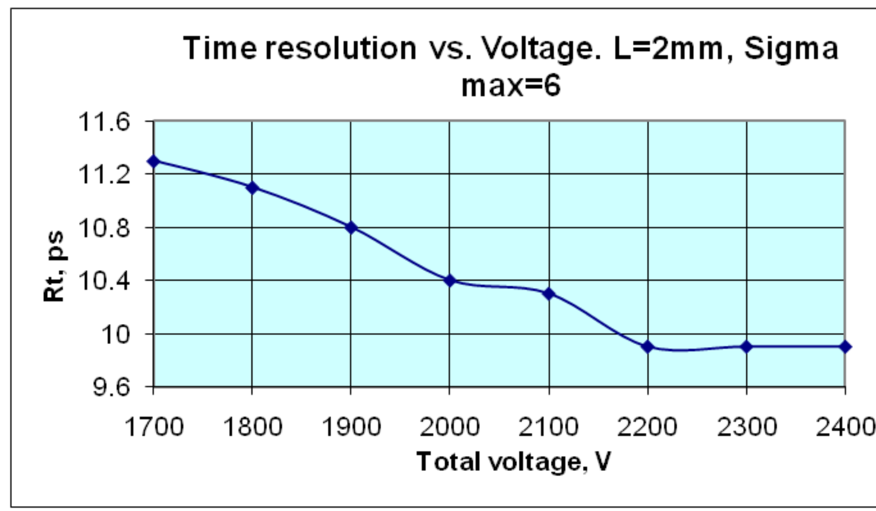
The photo multiplier from Burle/Photonics

# Effect of the voltage




Gain factor has an exponential growth vs. voltage, but transit time spread is decreasing in the voltage growth. All these simulations have been done for the pore diameter of 25 um.

# Effect of the gauge factor of the pores

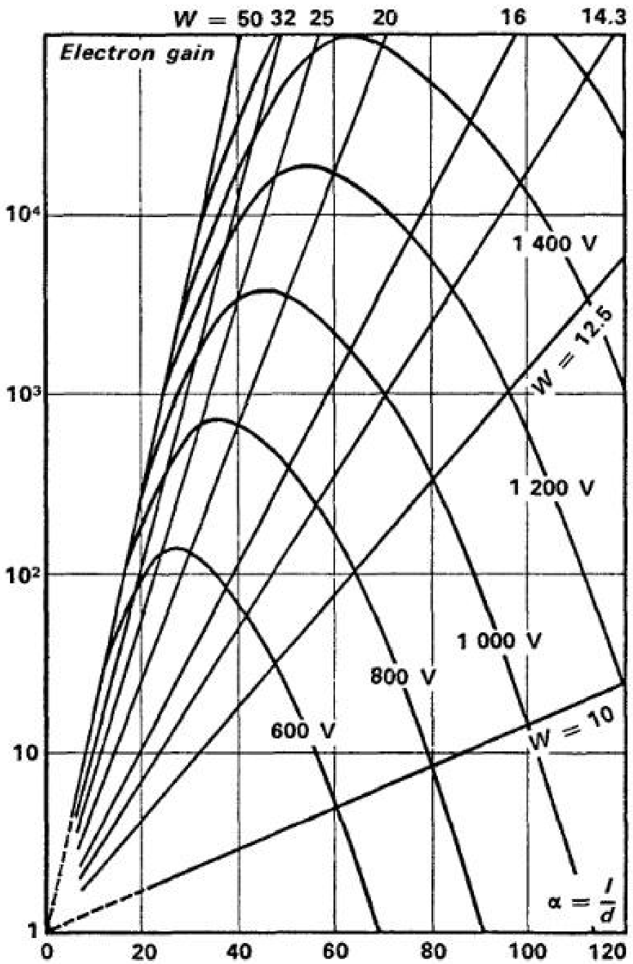



Fig. 2. Universal gain curve for a channel plate.
W = V/α ; primary electron energy = 2 000 eV.

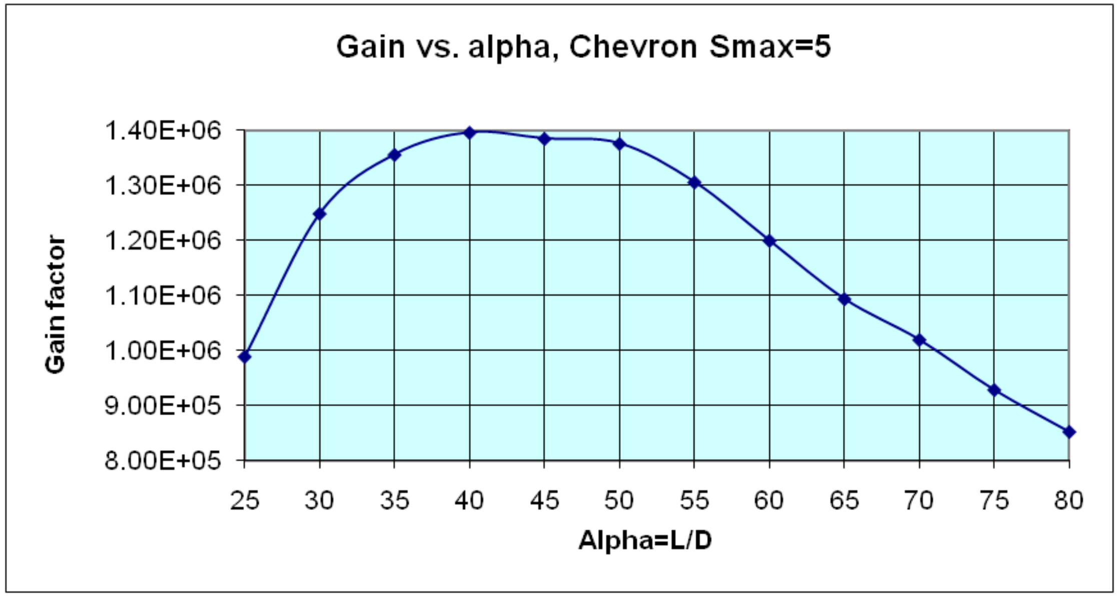
A.J.Guest. ACTA Electronica, V.14, N1, 1971, p. 85.

True secondary emission model by A.J.Guest

$$\sigma(V,\theta) = \left(\frac{V}{V_{\max}}\sqrt{C}\right)^{\beta} \exp\left[\alpha(1-C) + \beta\left(1 - \frac{V}{V_{\max}}\sqrt{C}\right)\right],$$

$$C = \cos(\theta)\sqrt{\frac{V_0}{V}}, \quad \beta = \begin{cases} 0.55, V < V_{\max}, \\ 0.25, V > V_{\max}. \end{cases}$$

Θ – incident angle; V- incident energy; α, β, Vmax -material properties




The result of numerical modeling with using the code MCPS (Micro Channel Plate Simulator)

# Effect of the secondary emitter properties

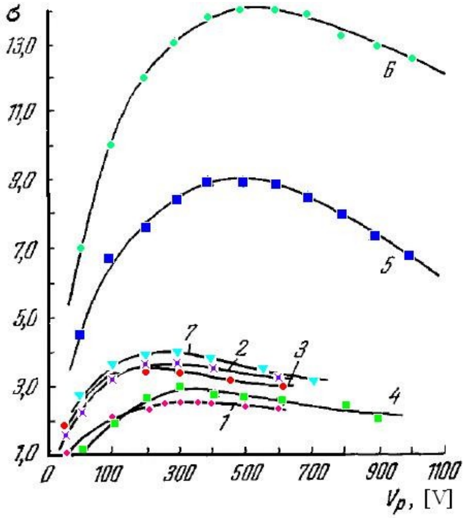



Fig.8. Secondary emission coefficient for some emitters. 1 - SnO2 with big excess of metal; 2 - SnO2 with less excess of metal; 3 - lead silicate glass, reduced in Hydrogen; 4 - beryllium bronze, pured with etching and tempered in 450 degrees in Celsium under pressure; 5 - BeO layer on the CuBe with normal emission; 6 - BeO layer on the CuBe with abnormal emission; 7 - BeO layer, obtained by oxidation of metallic Be.

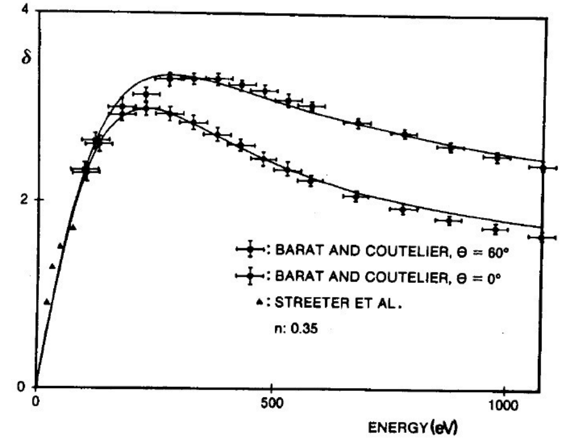
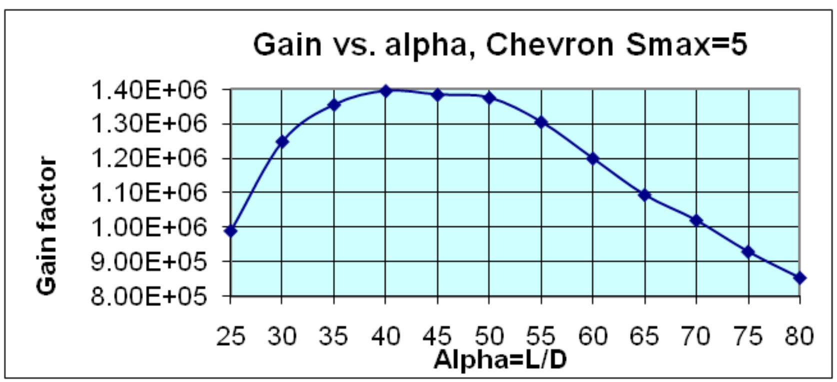
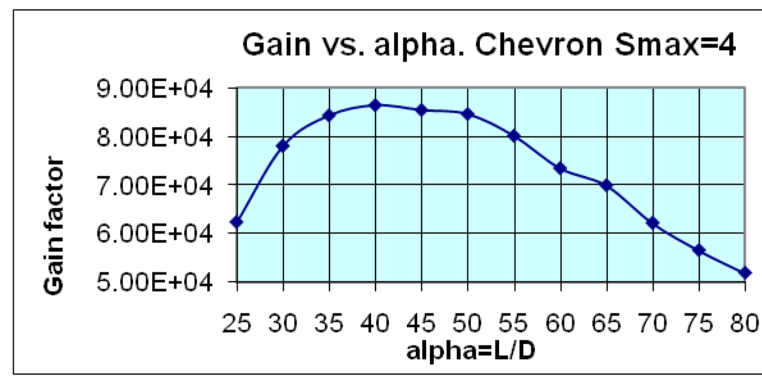



Fig. 5. Secondary electron emission coefficient of a reduced lead glass surface for 0° and 60° incidence of the primary electrons.

Left: SEE vs. incident energy Vp for different materials and technology; Right: SEE vs. Vp and incident angle. Data were provided by Z. Insepov.




Main MCP parameters drastically depends on the material of secondary emitter

# Effect of the photo cathode properties

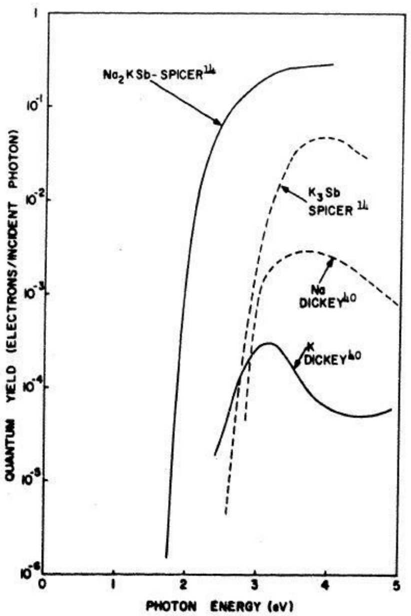



Figure 42 Spectral yield curves for K, Na, $K_3Sb$ and $Na_2KSb$.

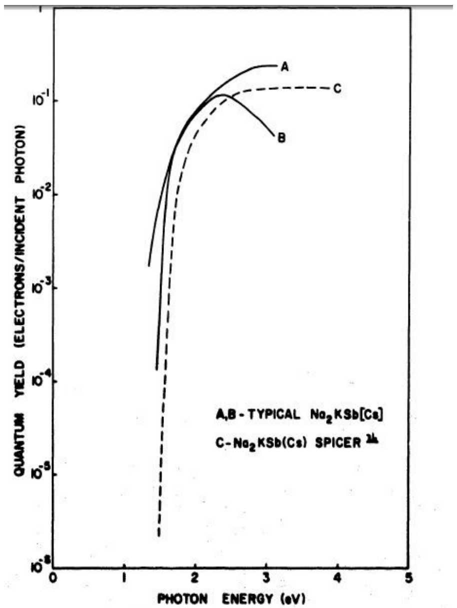



Figure 4 Spectral yield curves for $Na_2KSb(Cs)$.

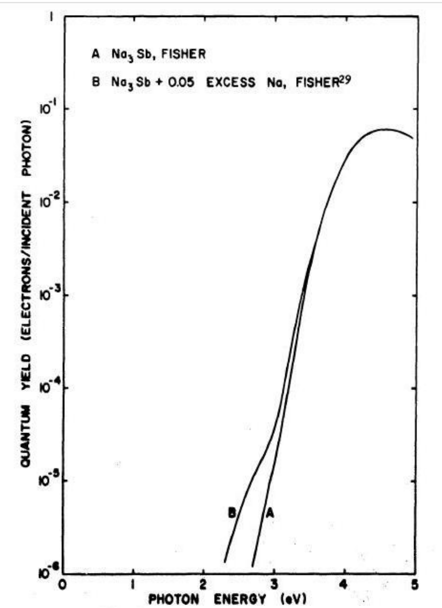



Figure 66 Spectral yield of $Na_3Sb$.

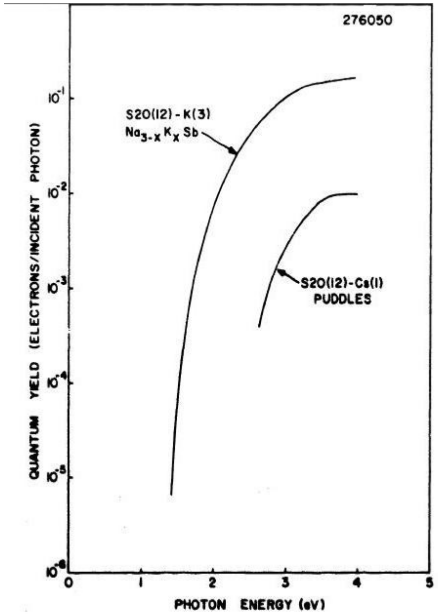



Figure 43 Change in spectral yield with excessive Cs deposition.

Photo cathode properties determine the input current for the MCP and time resolution.

# Other effects should be taken into account

- Noise factor limits the time resolution;
- Incident angle of secondary electron makes big changes for SEE; we have not enough data to simulate this effect more accurately
- 8 degree pitch of the pores in chevron-type MCP can produce an artifact comparing the straight pore in our simulation. We should estimate how big is this effect;
- 50um gap in between of 2 MCP plates should be taken into account in further simulations

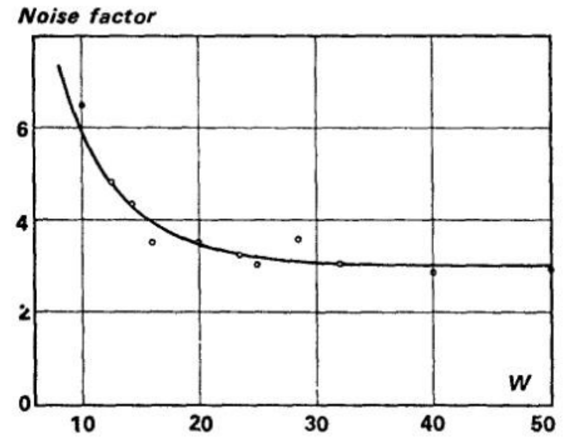



Fig. 5. Predicted variation of noise factor as a function of normalized voltage $W = V/\alpha$.
Primary electron energy = 2 000 eV ; $\gamma$ = 0.6.

A.J.Guest. ACTA Electronica, V.14, N1, 1971, p. 88

# Summary

- Main spatial and temporal properties of the industrial photomultiplier (from Burle/Photonics) with chevron-type MCP were studied by numerical modeling;
- The numerical results show that most important parameters (gain factor and time resolution) can be substantially improved by changing the gauge factor alpha=L/D, where L is a length of the pore and D is its diameter;
- The dependences of main MCP parameters on the gauge factor, voltage and properties of secondary emitter were studied numerically;
- Further works assume to improve the model to take into account the photo cathode properties to compute more accurately the time resolution, and to take into account the effect of the noise factor.