



**Muons, Inc.**



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# Computer code “Monte Carlo Simulator”, Windows Ver.2.0

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The code MCS is full 3D simulator with friendly user's interface and graphical post-processor. Numerical models include the angular, energy and spatial distributions for photo- and secondary emitters, fringe fields, saturation effects and other features representing different multi-layer materials. It can evaluate all parameters of realistic MCP devices: gain, transit time spread, angular, energy and spatial distributions of photo- and secondary electrons in pre defined cross-sections. Typical CPU-time for simulation of 1 million particles is 5 to 15 minutes at desktop or laptop computer with 1.8GHz CPU.

# Integrated User's Interface

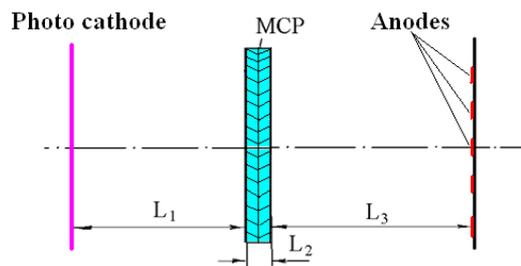
Micro Channel Plate Monte Carlo Simulator. V. 2.0

Photo emission	Plate 1	Plate 2	Plate 3	Anode	Secondary emission	Saturation	Cross-sections		
Rpc [um]	D [um]	D [um]	D [um]	Z [mm]	Sigma max	Io [mkA]	Ncross		
100.0	20.0	20.0	0.00	1.70	6.23	0.001	1		
Zpc [um]	U [V]	U [V]	U [V]	U [V]	E max [eV]	Ir [mkA]	Crs type		
950.0	1000	1000	0.00	500	350	0.01	Distribut		
Q yield	Gap [um]	Gap [um]	Gap [um]	Gap [um]	Esmax [eV]	tau [us]	Crs list		
4.00	100.0	0.00	0.00	3.00	3.00	0.1	200.0		
<X> [um]	Zo [mm]	Zo [mm]	Zo [mm]	R [MDhm]			Nangular		
0.00	1.00	701.0	0.00	100			20		
<Y> [um]	Yo [mm]	Yo [mm]	Yo [mm]	Tpulse [ps]			Nenergy		
-9.00	0.00	25.0	0.00	1.00			20		
En max [eV]	L [mm]	L [mm]	L [mm]	dt [ps]			Ncurrnt		
0.30	600	600	0.00	0.1			20		
Sigma	Bias [deg]	Bias [deg]	Bias [deg]	Gain			Graphic screen		
2.5E-6	8.00	-8.00	0.00	1.E6			Xmin		
Nparticle	Beta [deg]	Beta [deg]	Beta [deg]	alpha			0.9		
5	8.00	-8.00	0.00	1.5			X max		
Ugap [V]	Fringe fld	Fringe fld	Fringe fld	Tmax [ps]			2.1		
350.0	Field1	Field2	0.00	100			Ymin		
MCP type	Delta [um]	Delta [um]	Delta [um]	N time			0.0		
Chevron	0.00	0.00	0.00	100			1.5		
Task name	Dist [um]	Dist [um]	Dist [um]	Comm					
Saturn	25.0	25.0	0.00	Saturation st.					
				Open	Save	Saturation	Run	Show	Exit

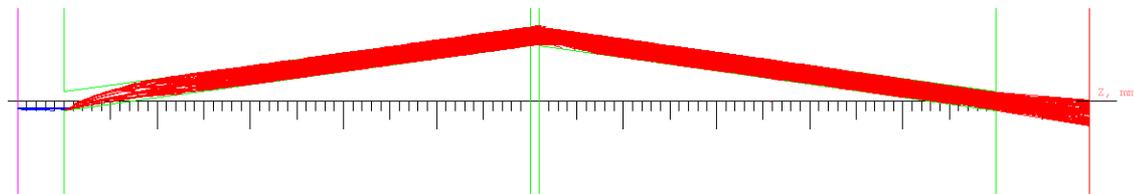
Using the Interface one can easily input/edit the data, run the problem, look at the graphical results, and repeat the computational cycle.

# The effect of inter-plate gap variation

The normal way to reduce the saturation effects is to introduce the low-resistance layer coating the channel surface. Another way is to vary inter-plate gap of chevron pair or Z-stack in order to distribute the secondary electrons from one pore of 1-st plate to many channels of the 2-nd and 3-rd plates. By this way one can reduce the currents in each individual pore of last cascades, and keep the total gain.



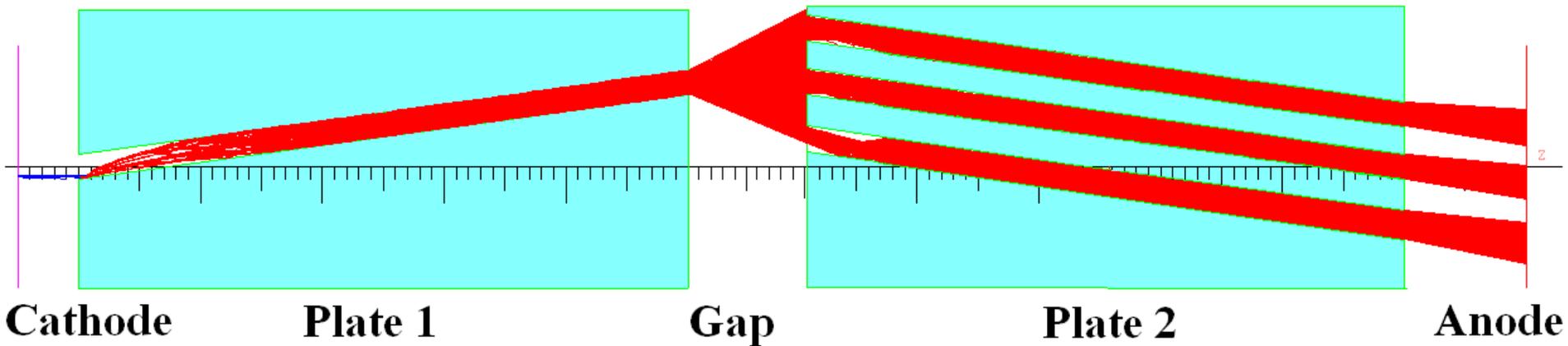
MCP amplifier sketch.



Small gap. Electrons from 1-st plate come to one pore of 2-nd plate. Gain  $M=1.2E6$  for  $\tau=1\mu s$ , and  $M=1.5E5$  for  $\tau=1ms$ . Blue – photo electrons; red – secondary electrons.

# The effect of the gap variation (2)

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Large gap. Electrons distributed to 3 pores of 2-nd plate. Gain  $M=3.4E6$  for  $\tau=1\mu s$ , and  $M=1.03E6$  for  $\tau=1ms$ .

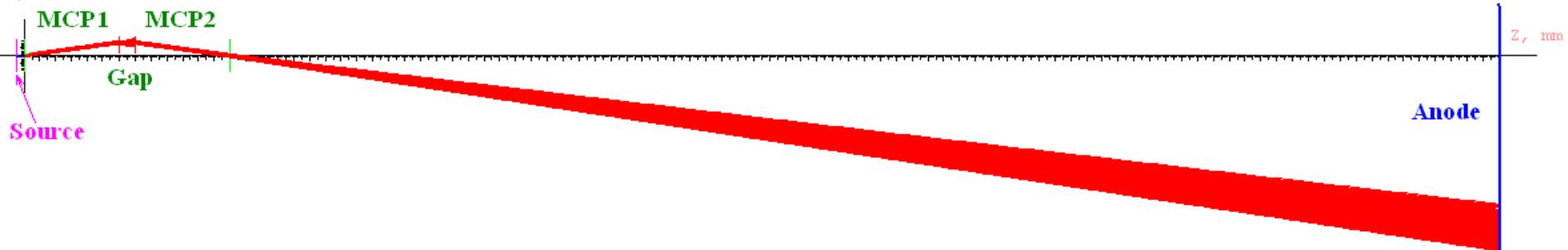
# MCP Specifications

Photocathode	
direct photo-excitation on chrome electrode coating. No extraction voltage	

## Channel Plate Assembly

Voltage on MCP 1	800-1200 V
Gap Between MCPs	100 microns
Voltage across MCP Gap	none
Voltage on MCP 2	800-1200 V
MCP-Anode Gap	~8 mm
Volage on Anode Gap	800 V

Channel Plates				
MCP 72				
pore diameter	thickness	L/D	open area ratio	
20 micron	1.2 mm	60	60%	
resistance	SEE material	bias angle		
1 GigaOhm	Al2O3	8 degrees		
electrode:	chrome layer on top of ALD			
MCP 78				
pore diameter	thickness	L/D	open area ratio	
20 micron	1.2 mm	60	60%	
resistance	SEE material	bias angle		
1 GigaOhm	Al2O3	8 degrees		
electrode:	chrome layer underneath ALD			

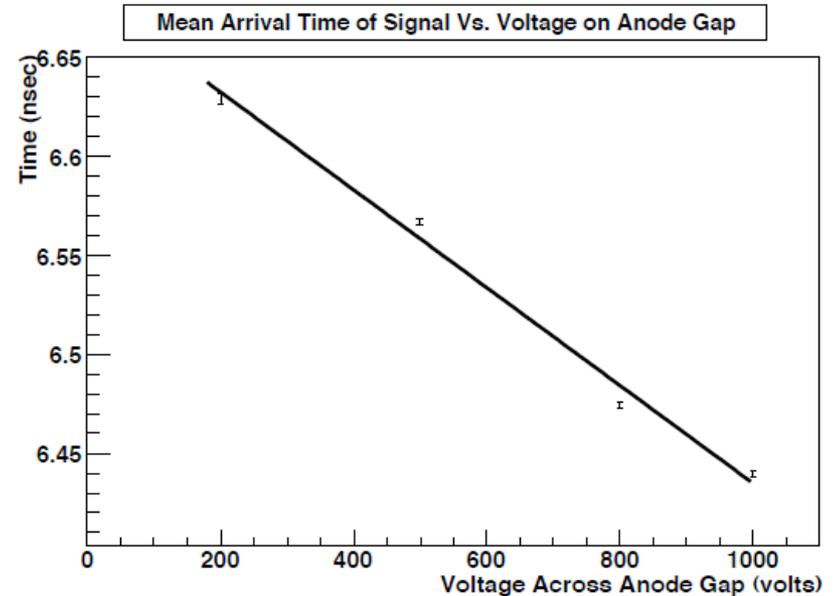
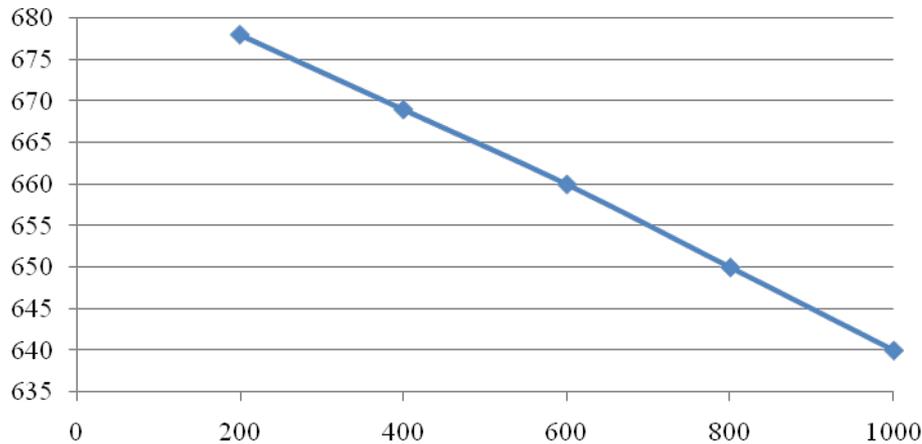


An example of the MCP simulation

# Simulation vs. experiment

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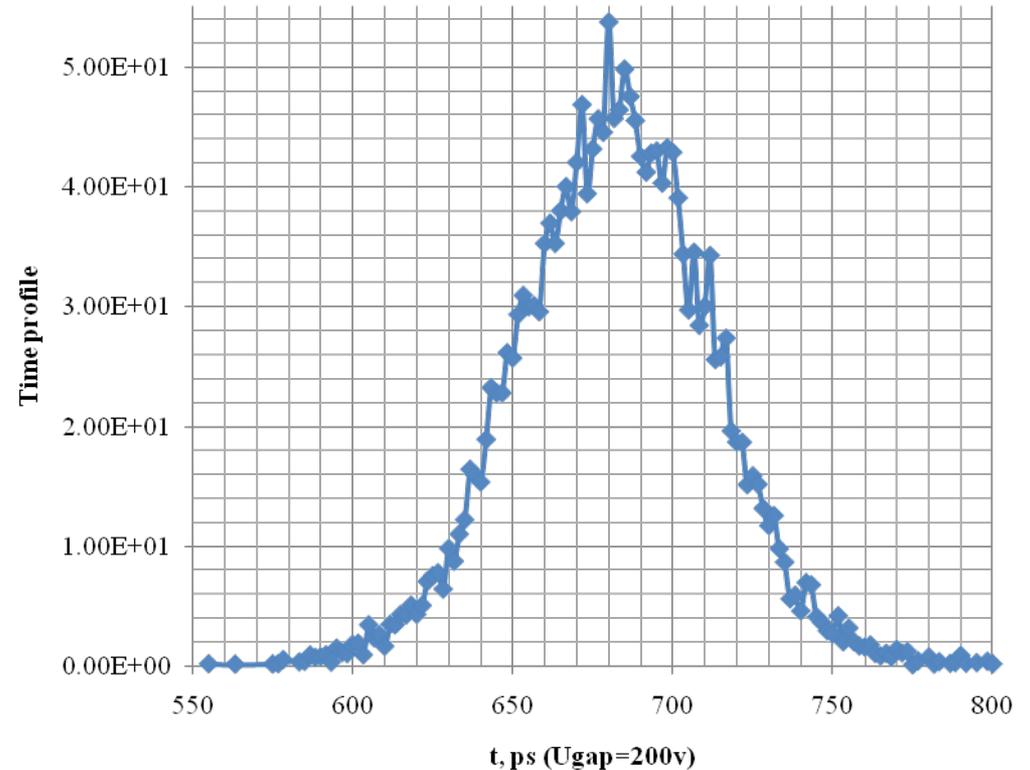
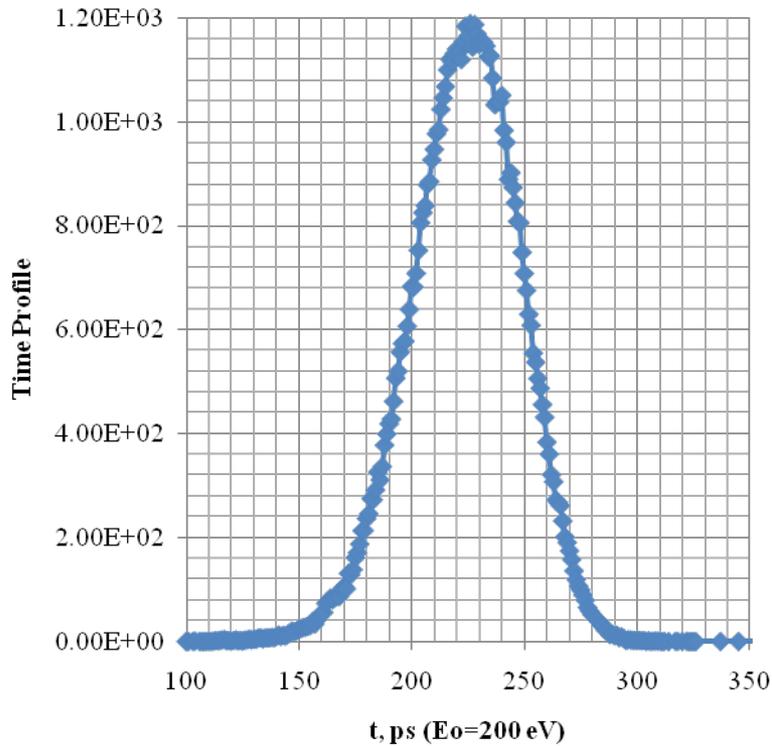
Mean arrival time [ps] vs. Anode Gap Voltage [V]



Simulations (left) & experiment (right) by M. Wetstein. Probable reasons for the difference are space charge effects or induced surface charges (saturation).

# Evolution of the pulse shape

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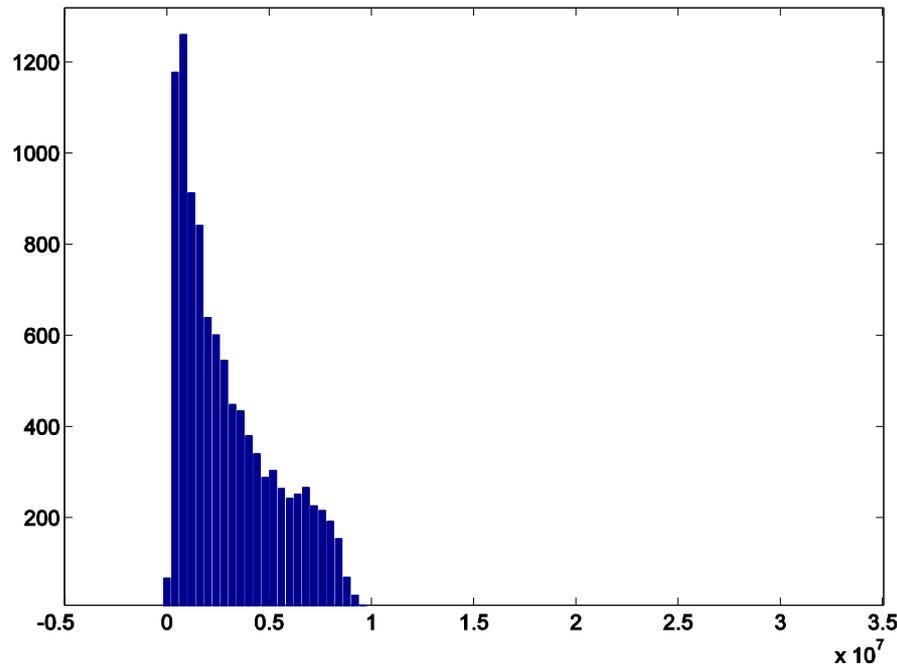


Time profiles for the pulse in the inter-plate gap (left) and at the anode (right)

# Challenging problem for the future simulations

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Pulse Height Distribution for MCP 64/65 Chevron at 1.3 kV Per Plate



The experimental histogram shows the statistics of the gain distribution for a several thousand single photo electrons. In order to reproduce this statistics in simulations we should implement the parallel version of the code, because simulation of each event takes about 15 min. of CPU time.