5μm pore Microchannel Plate and its performance

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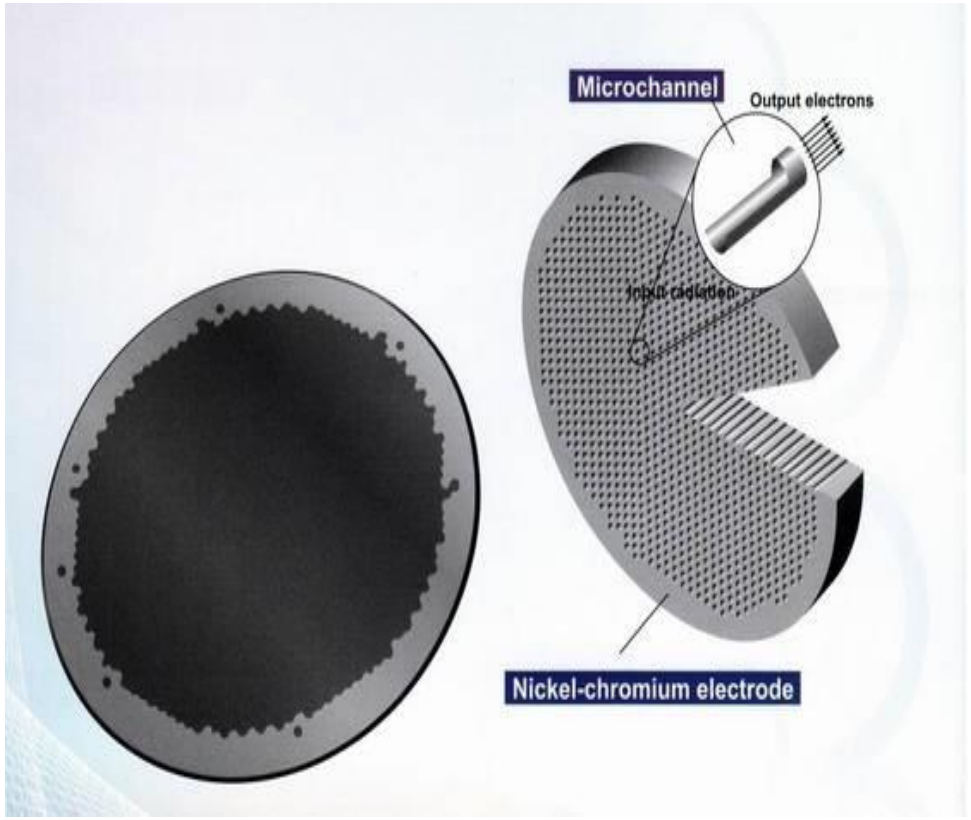
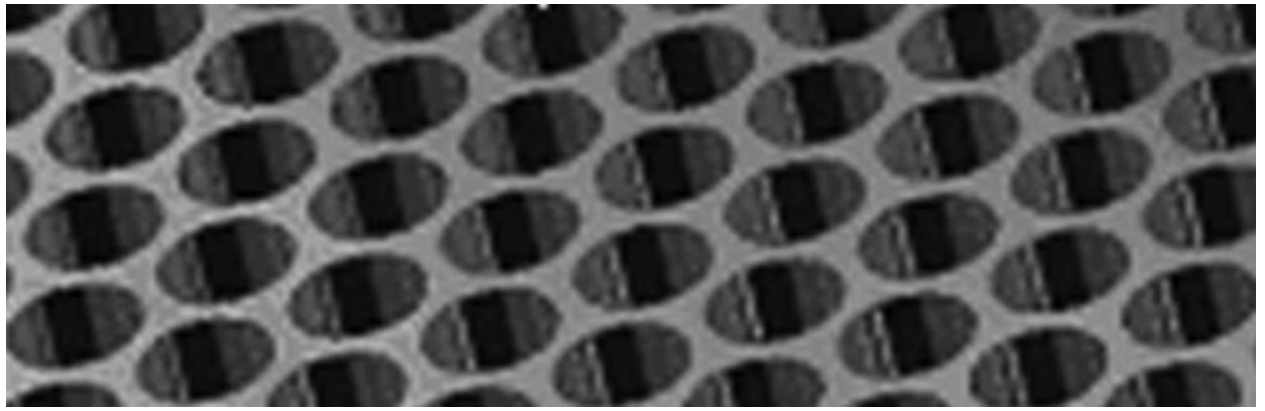
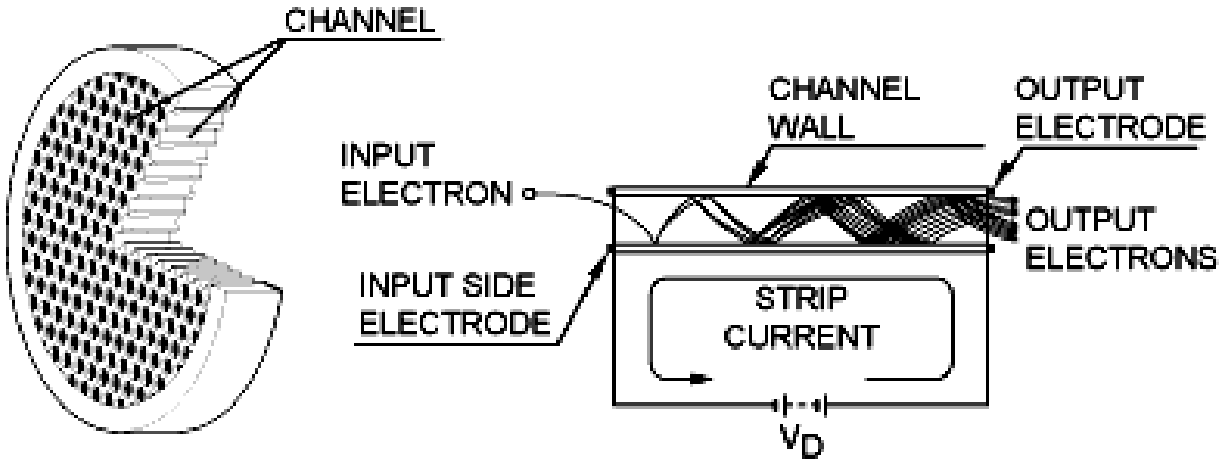
6. Can we expect to use the ultra small pore MCP to make MCP-PMT in the CEPC EM calorimter, we are exploring…

summary

1. Microchannel plate and its physical mechanism to realize electron multiplication







Microchannel Plate (after abbreviation MCP) is an electron multiplier that detects and multiplies electrons in two dimensions. MCP is also sensitive to ions, vacuum UV rays, X-rays and gamma rays and so can also be used as devices to detect their position and energy.

2.Application and development trend of microchannel plate

2.1 main application fields

national defense

Image intensifier

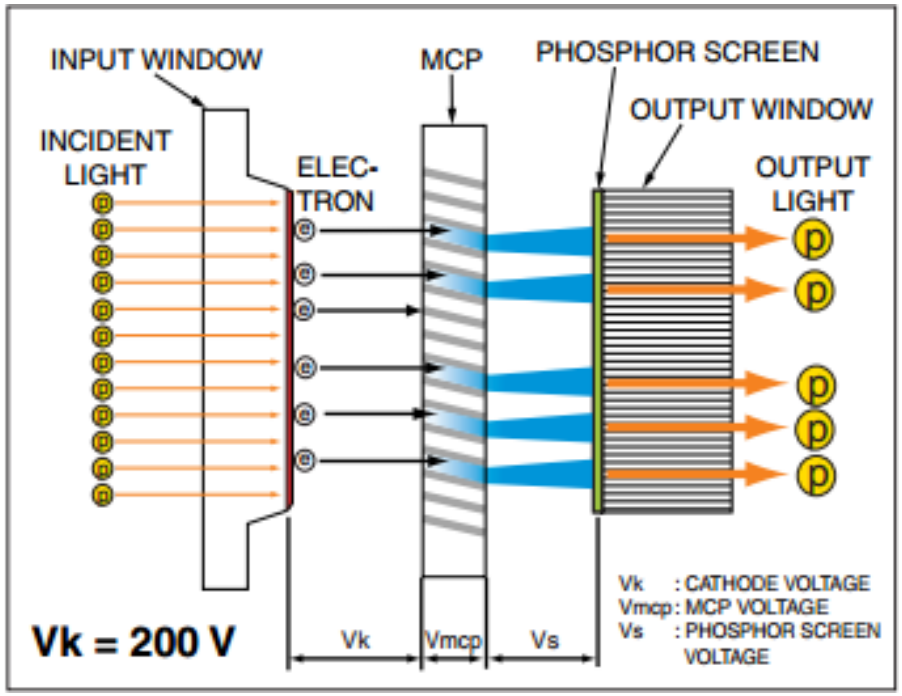
MCP-PMT

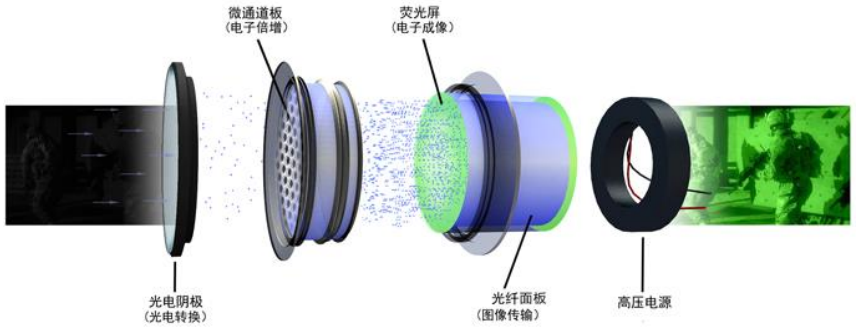
High energy physics and other ultra fast detection fields

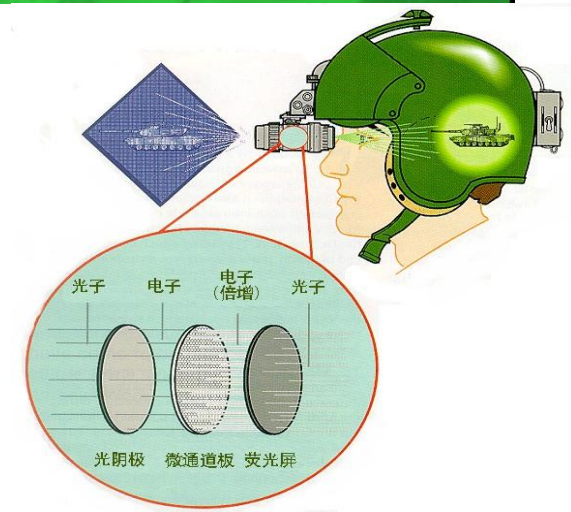
Other MCP imaging and detector parts and systems

Precision medicine and other national economy and people's livelihood

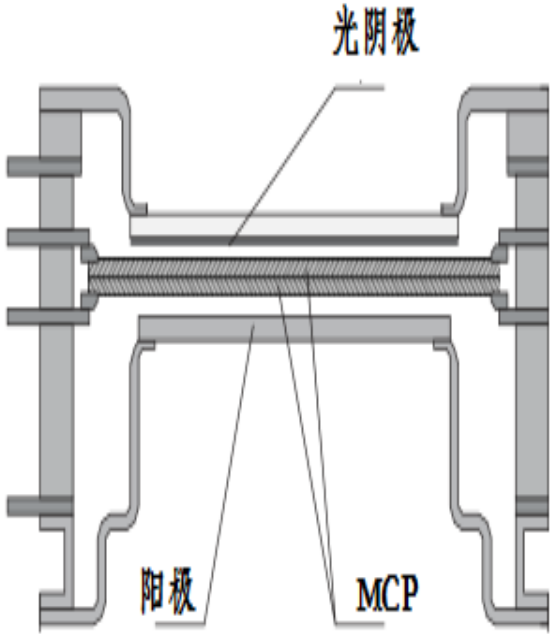
2.1.1 **Image intensifier----**MCP's largest application field

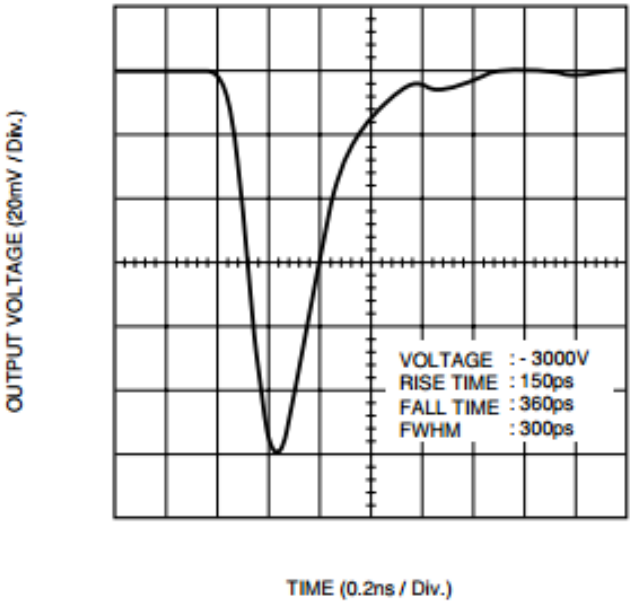




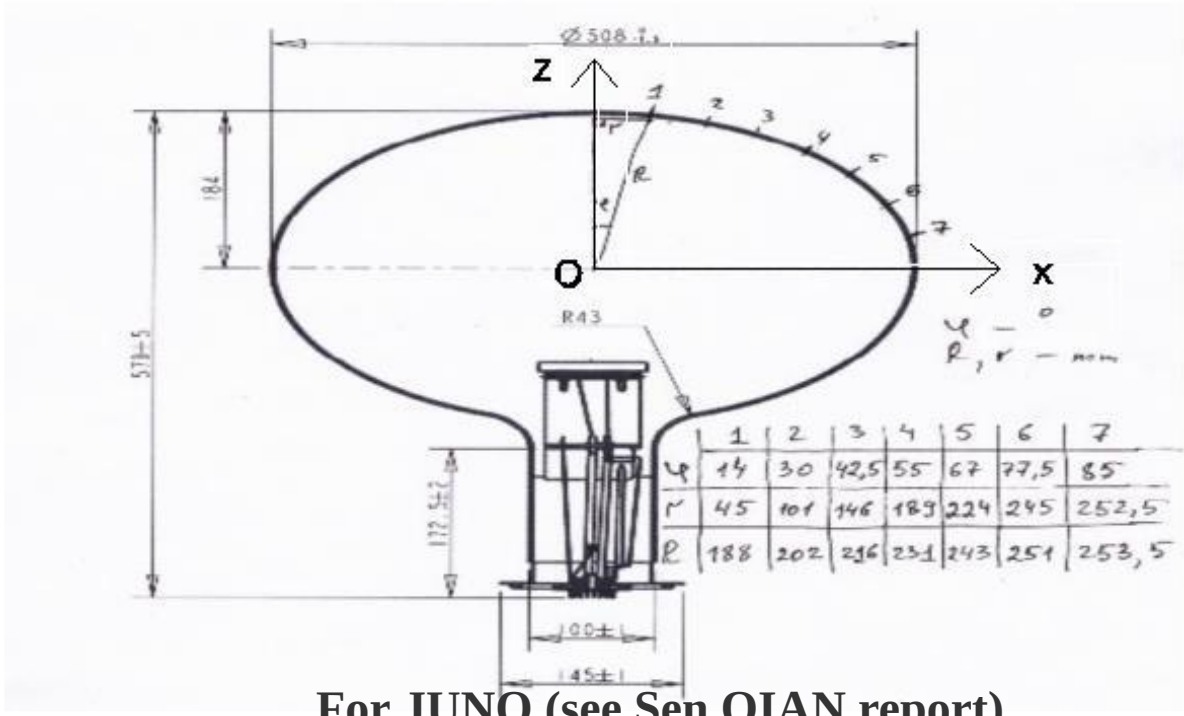


2.1.2 MCP-PMT





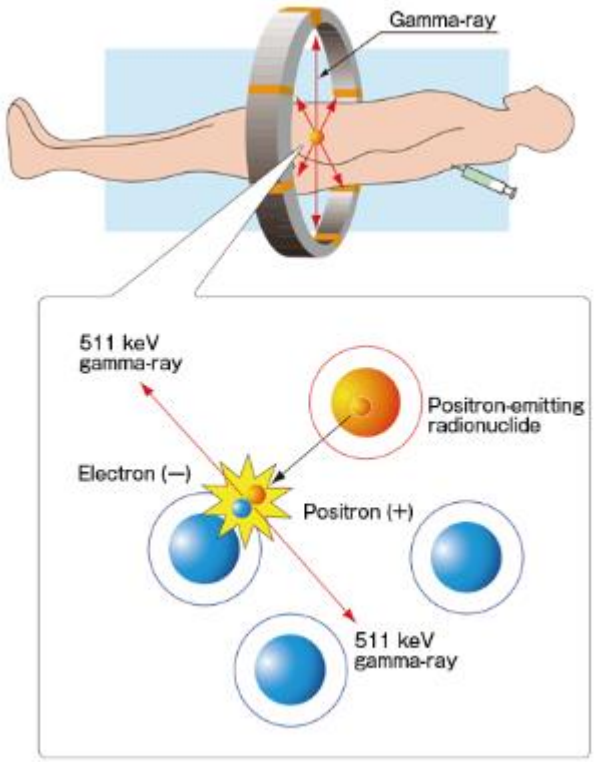
proximity focusing MCP-PMT



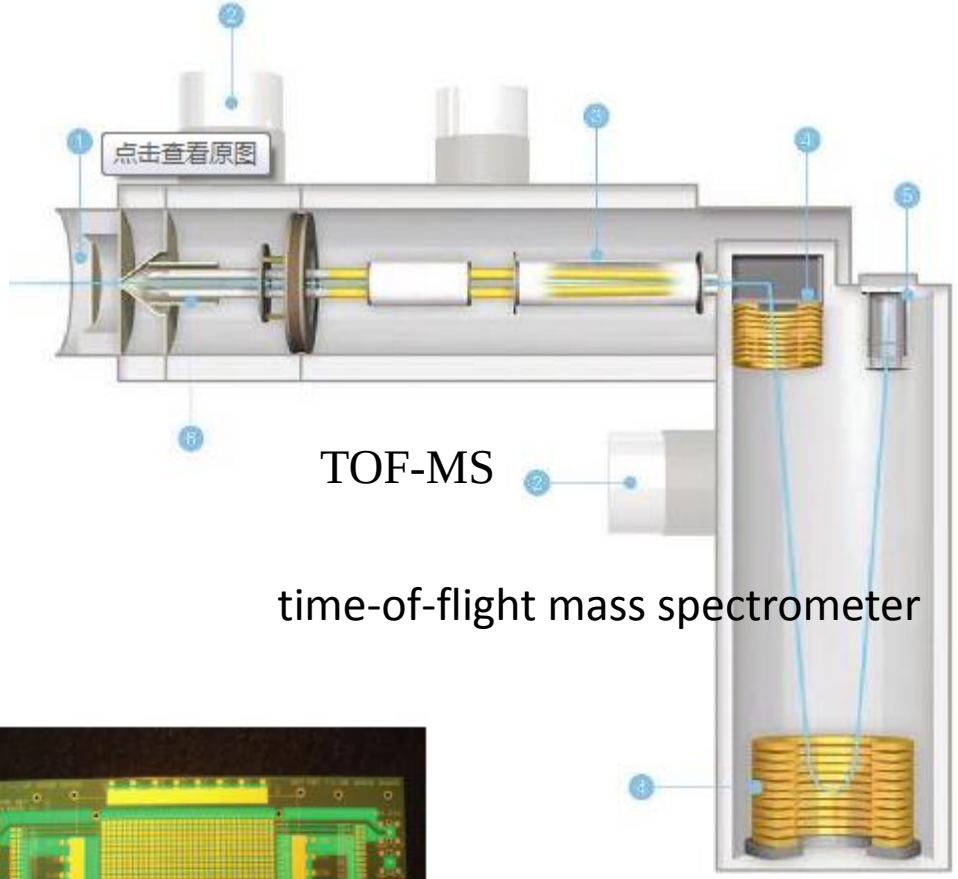
For JUNO (see Sen QIAN report)

electrostatic focusing MCP-PMT

2.1.3 Other MCP imaging and detector parts and systems

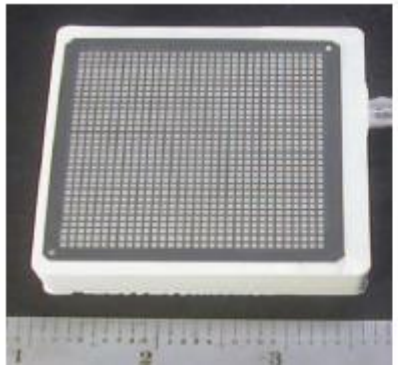


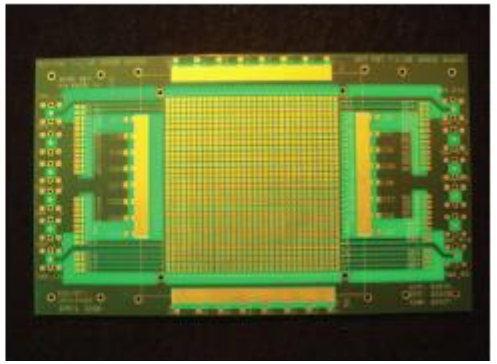
PET



TOF-MS

time-of-flight mass spectrometer





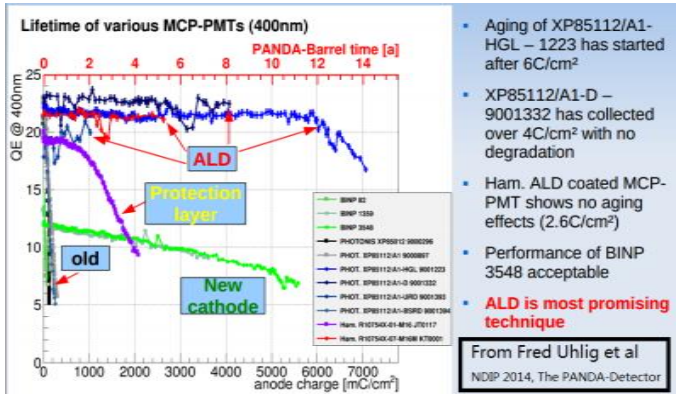
Accelerators and synchrotron radiation detectors

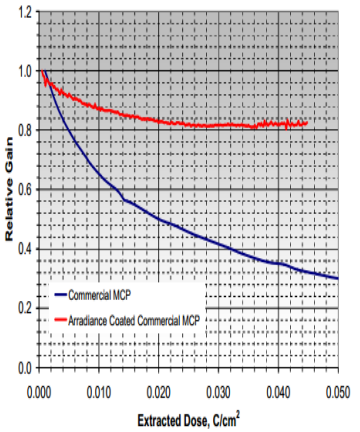
2.2 **Development trend of microchannel plate**

- From Small pore to ultra-small pore : 15**μm**⟶12**μm**⟶**10μm**⟶**8μm** ⟶ **6μm** ⟶ **5μm, and so on** to improve spatial resolution and time resolution
- Low noise: ~0.1count/cm^{2}s ⟶ ~ 0.01count/cm^{2}s
- High gain: electron gain ~10^2~10^3~10^4

Large dynamic range:

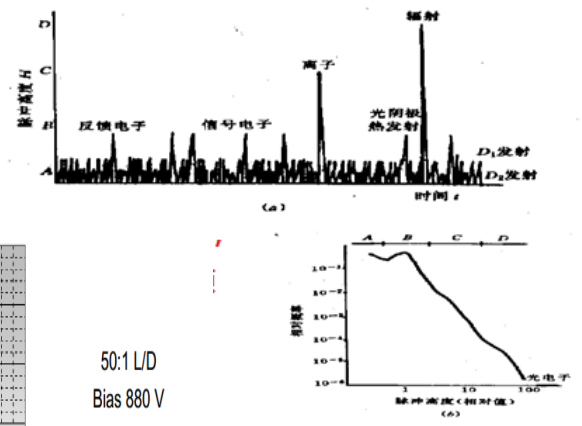
Long life : C- 10C-100C?





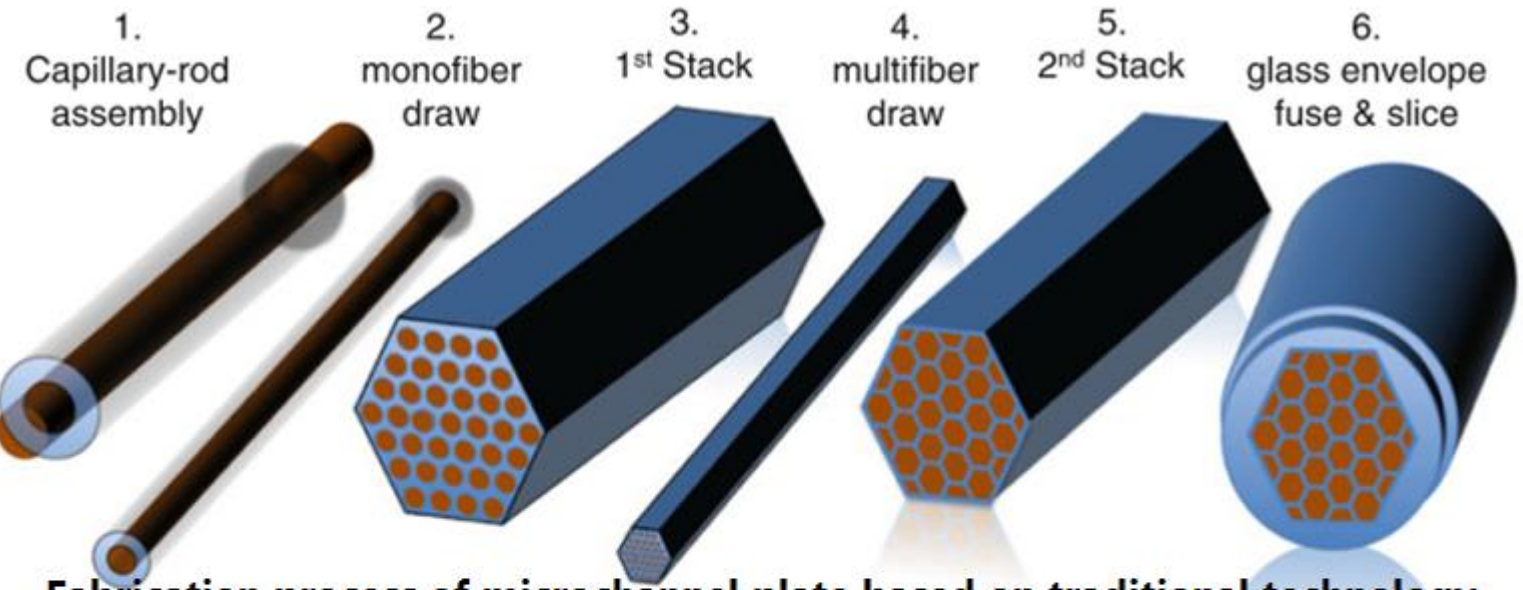
50:1 L/D
Bias 880 V
18 mm active area
4.8 μm pores
R ~ 100-200 MΩ
I_{out} ~ 10-20% I_{strip}

Applied over commercial glass MCPs

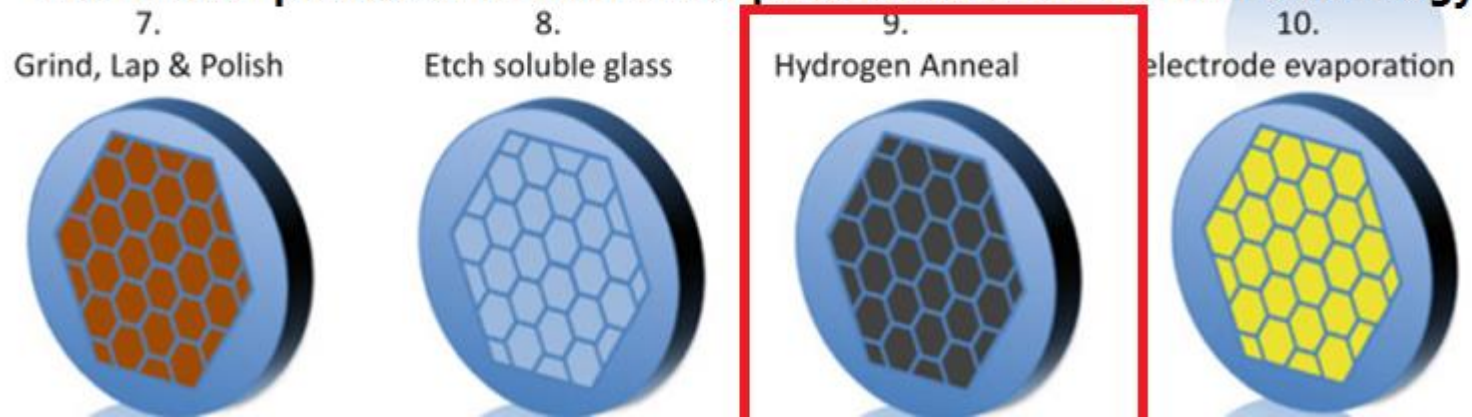


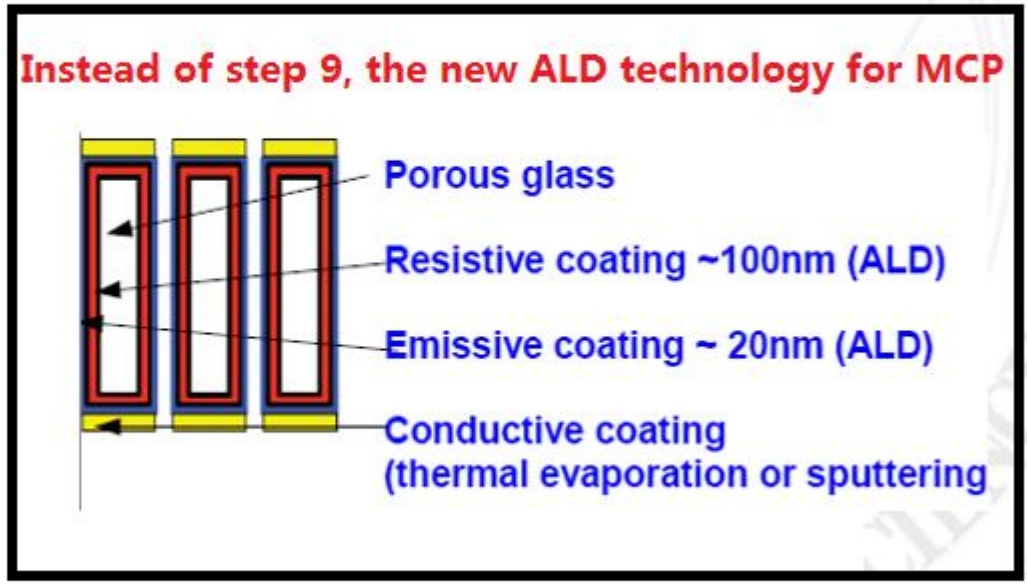
3. Making process of MCP

（traditional technology and the new technology made of MCP）



Fabrication process of microchannel plate based on traditional technology

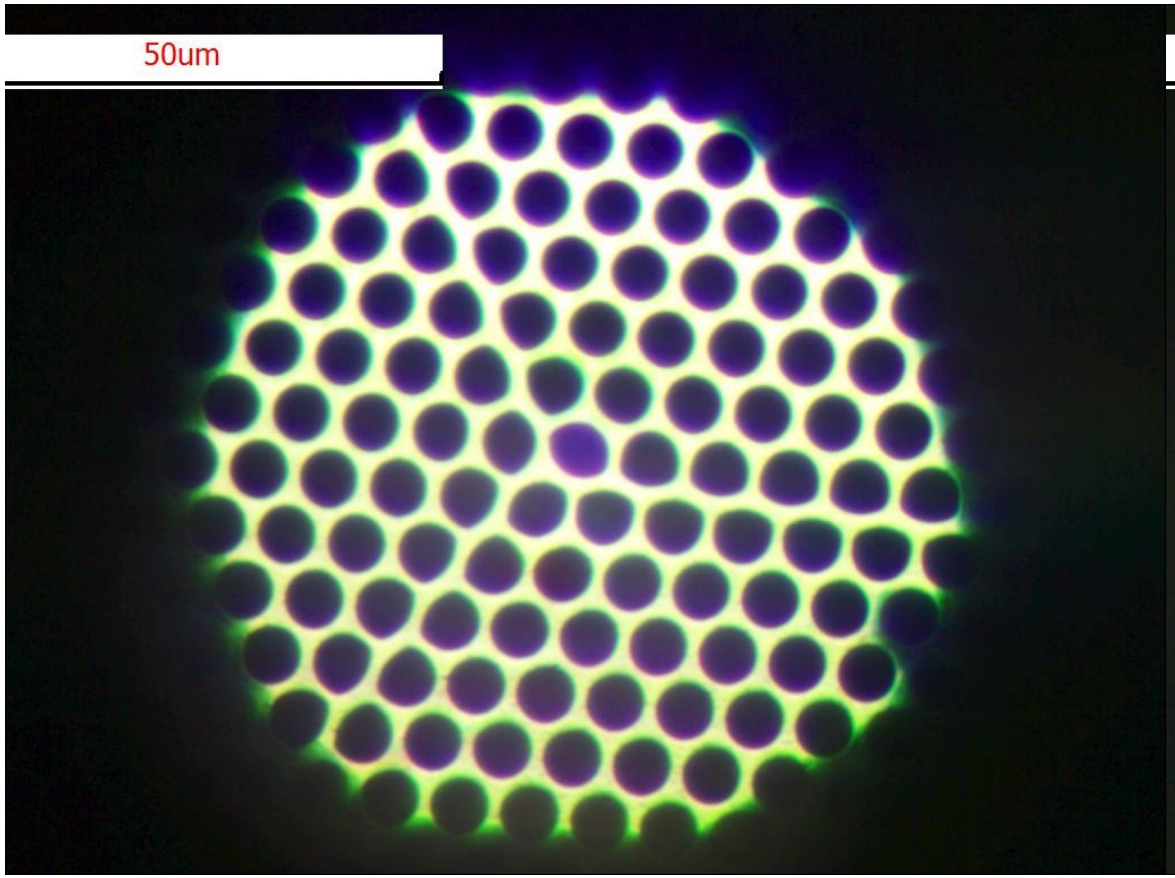




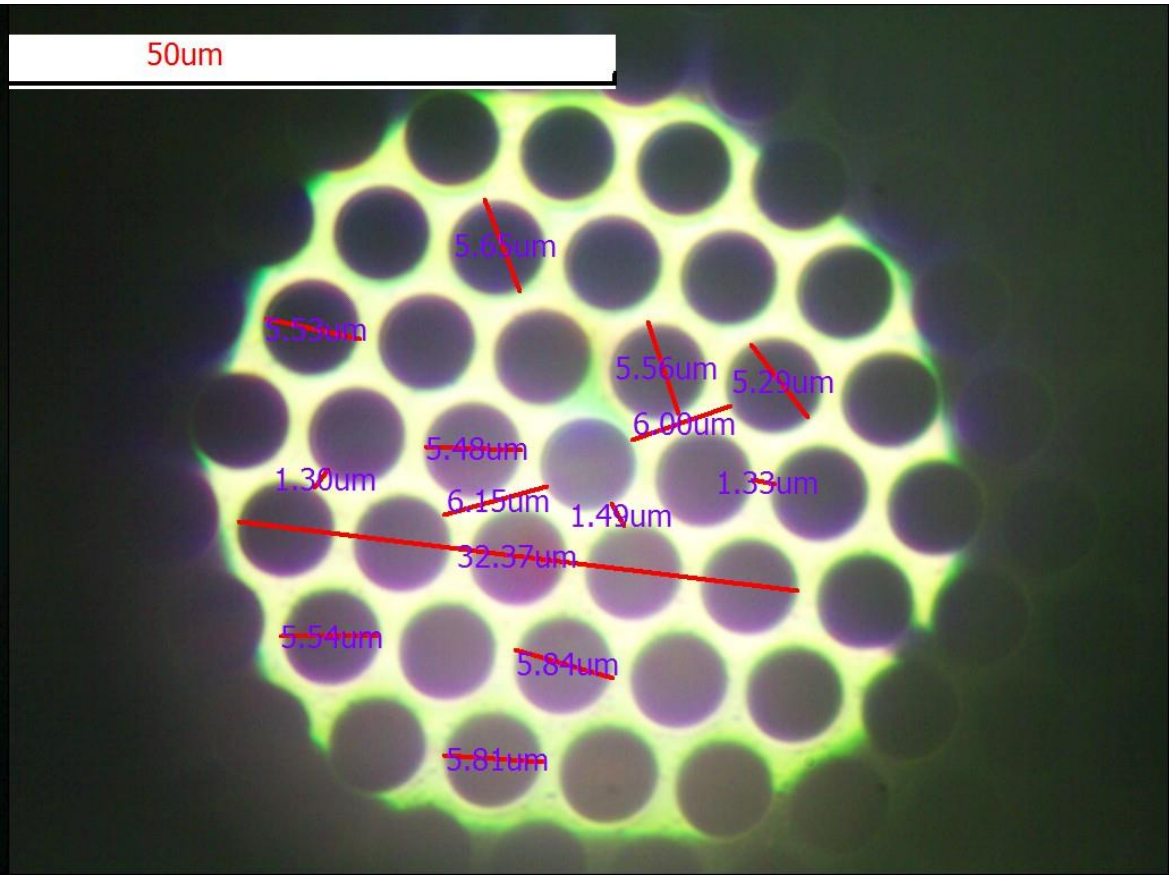
4.Main technical parameter for 5 μm from traditional technology

Outer diameter: Φ24.80±0.04（mm）； useful diameter: ≥Φ18（mm）； pore：5±0.5（μm）；pitch：6±0.5（μm）； bis angle：6°±0.5°； thichness：0.30±0.02（mm）； resistance（500V）：50~300（MΩ）； gain（800V）：≥3000； quality for field of sight：Uniform and no defects and the launch point； **surface quality**：OK

4.1 MCP local micrograph

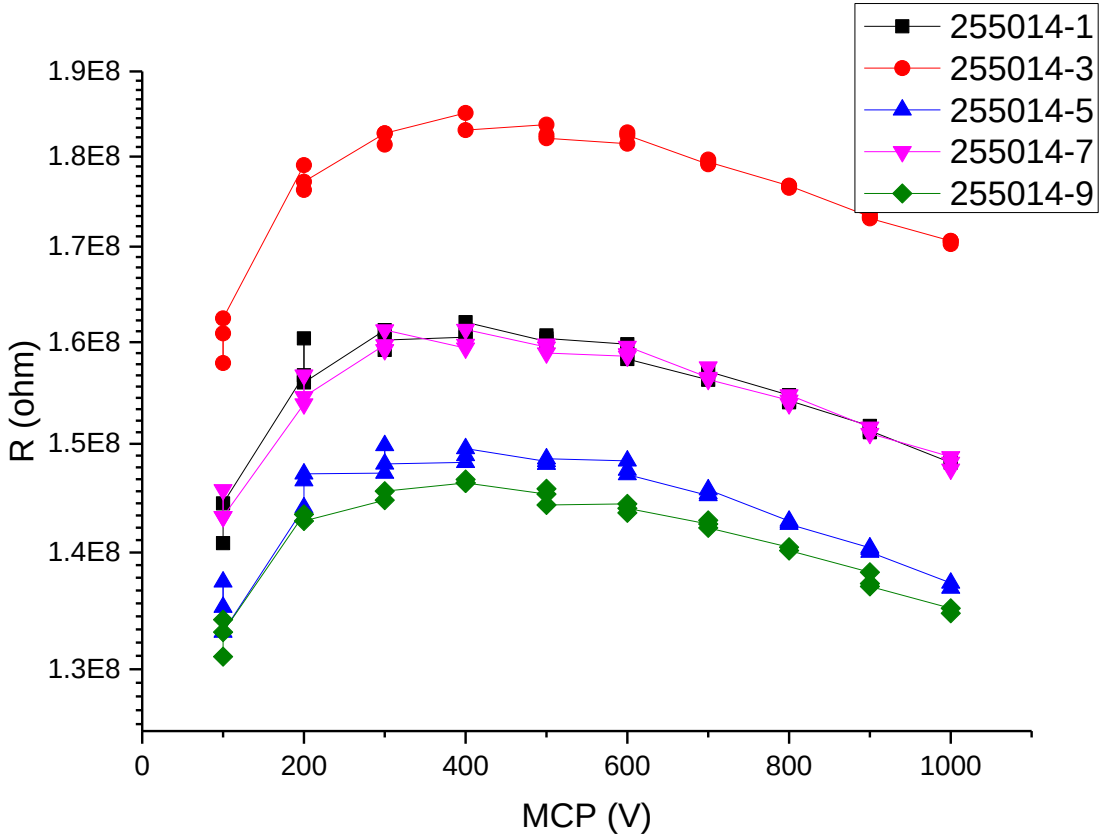


60X

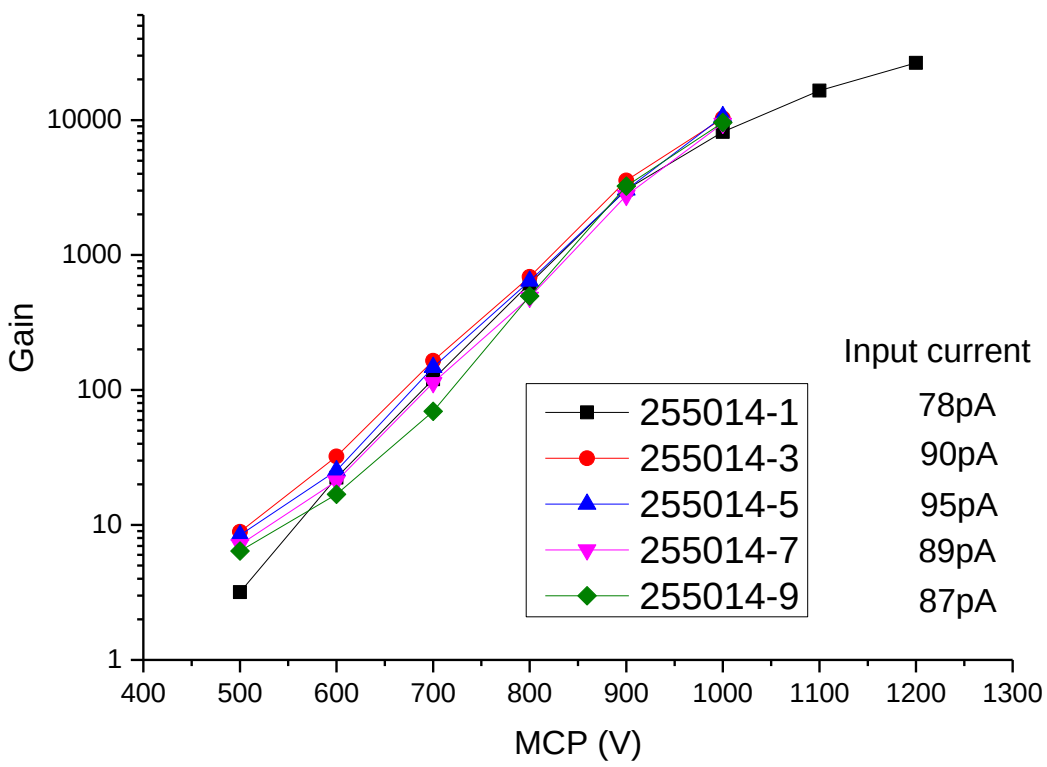


100X

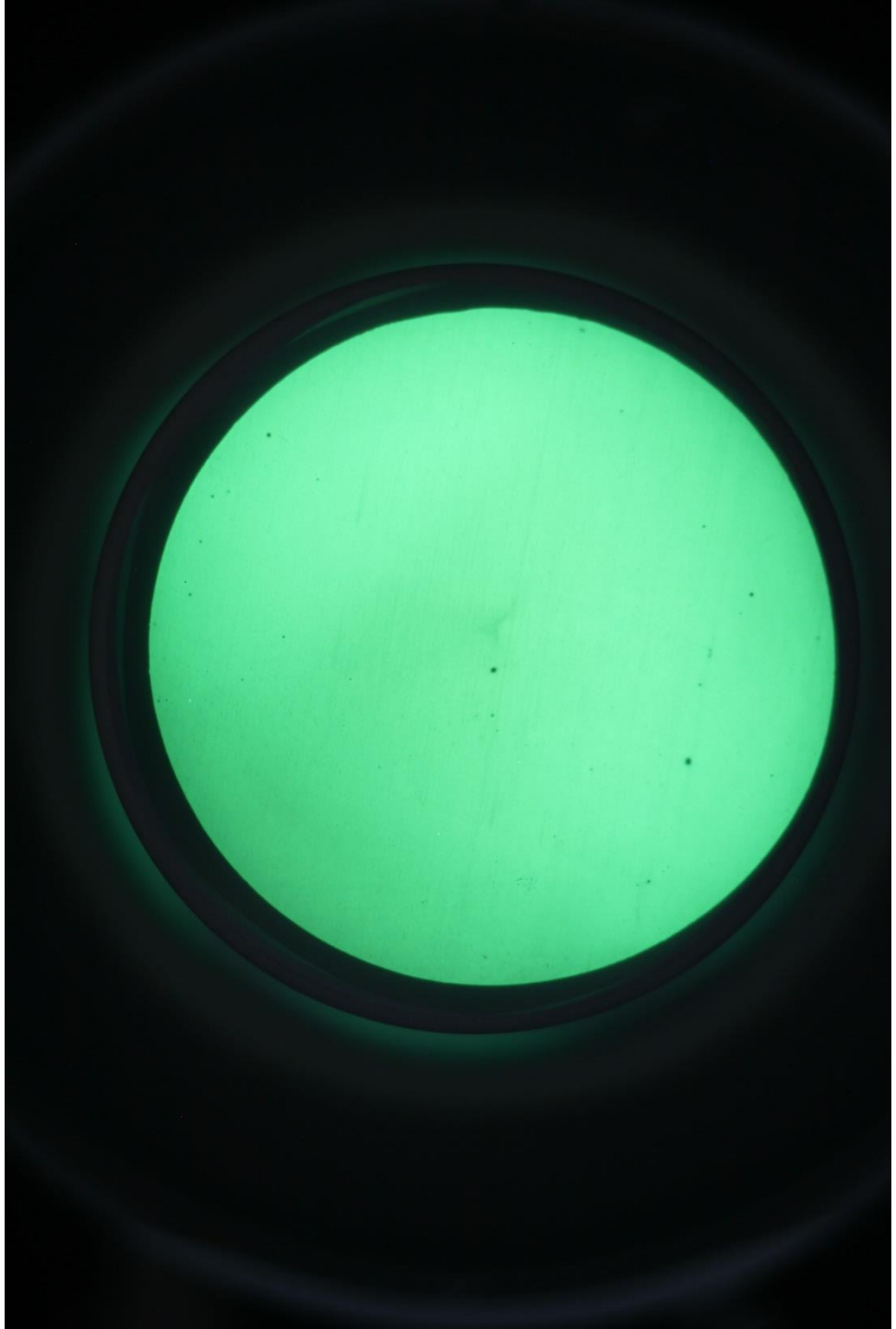
4.2Resistance and gain (traditional technology)



Resistance~MCP Voltage



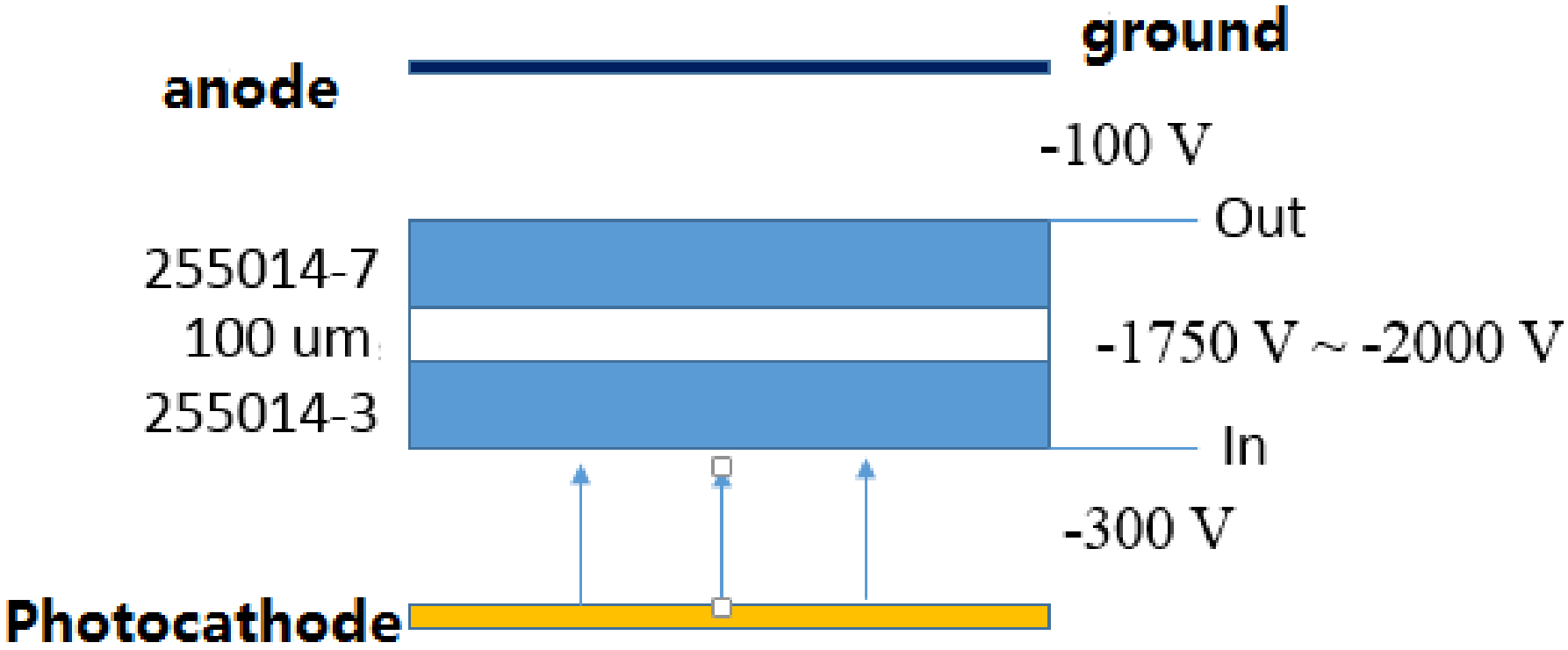
The relationship between current gain and voltage



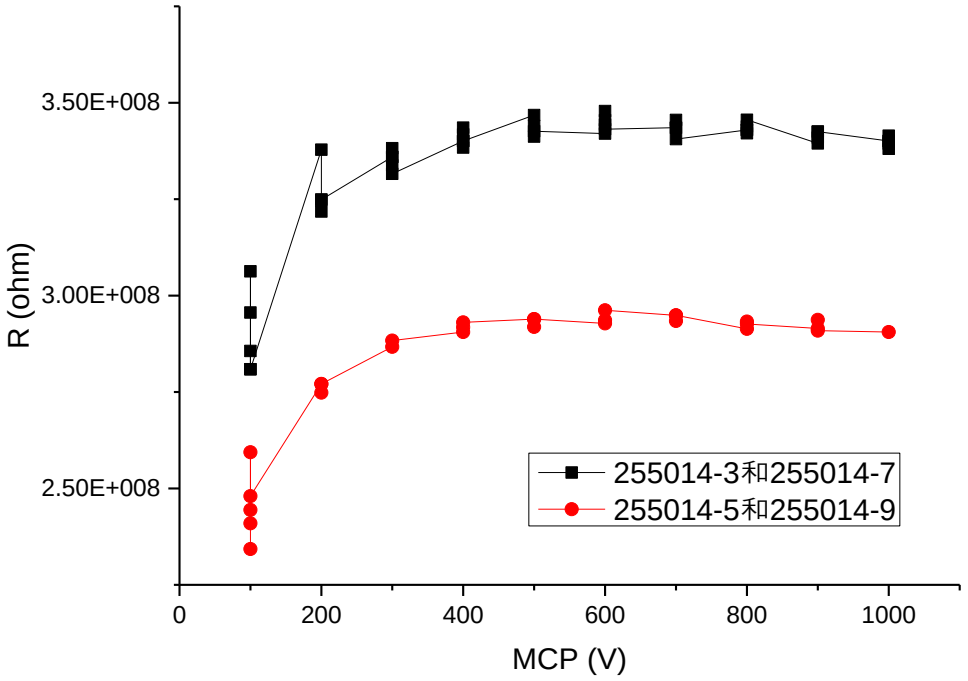
this picture is our MCP's visual image displayed under phosphor screen.

it can be seen that the uniformity of the gain is good.

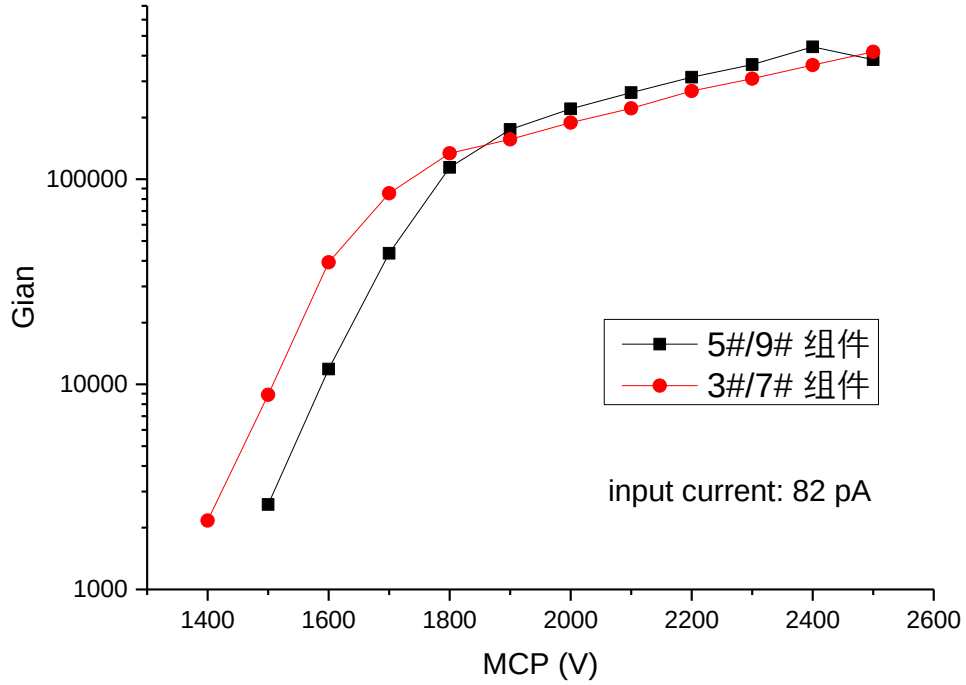
4.3 Two pieces of MCP constitute the assembly, the form of which is as follows



4.4 Resistance and gain of the assembly(traditional technology)

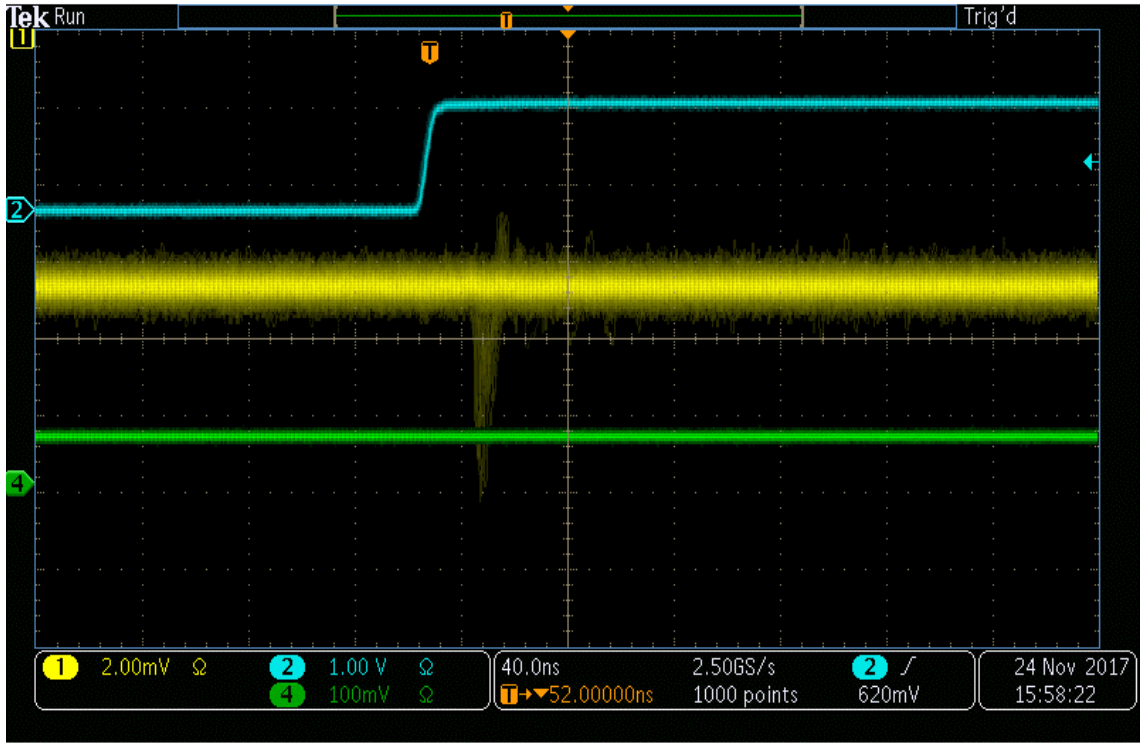


Resistance~voltage of MCP assembly



Gain~voltage of MCP assembly

4.5 Pulse performance test of assembly



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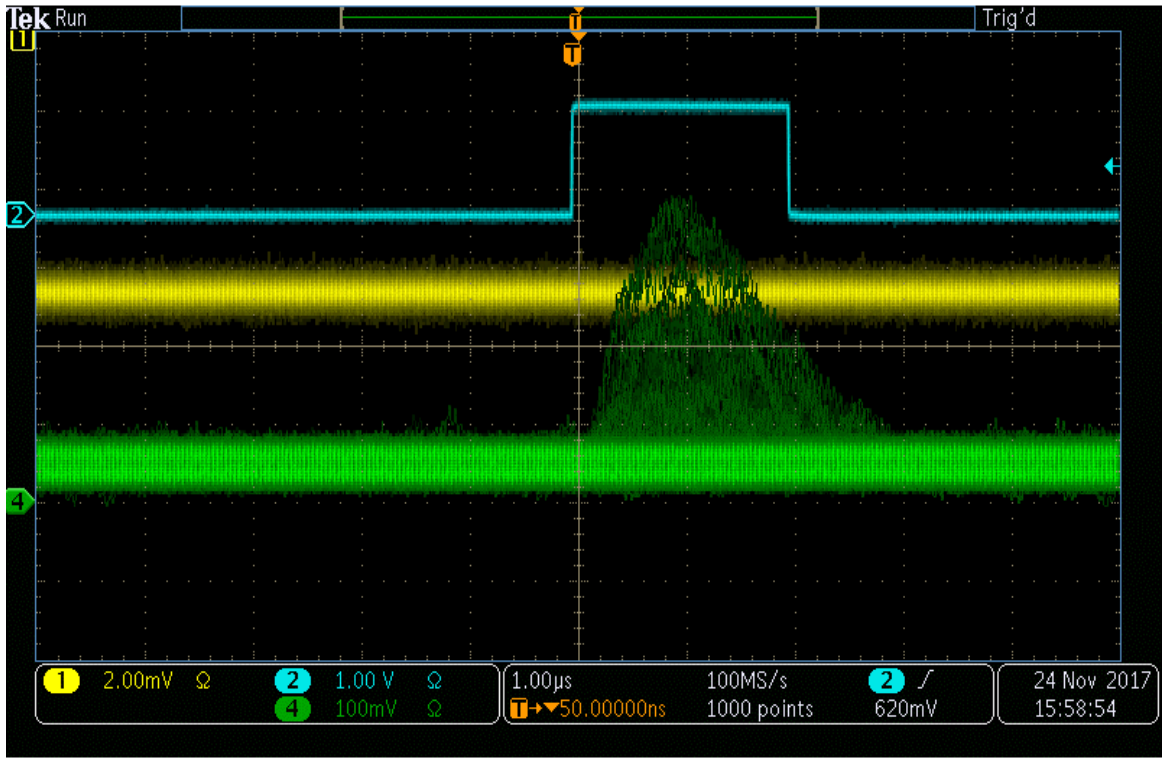
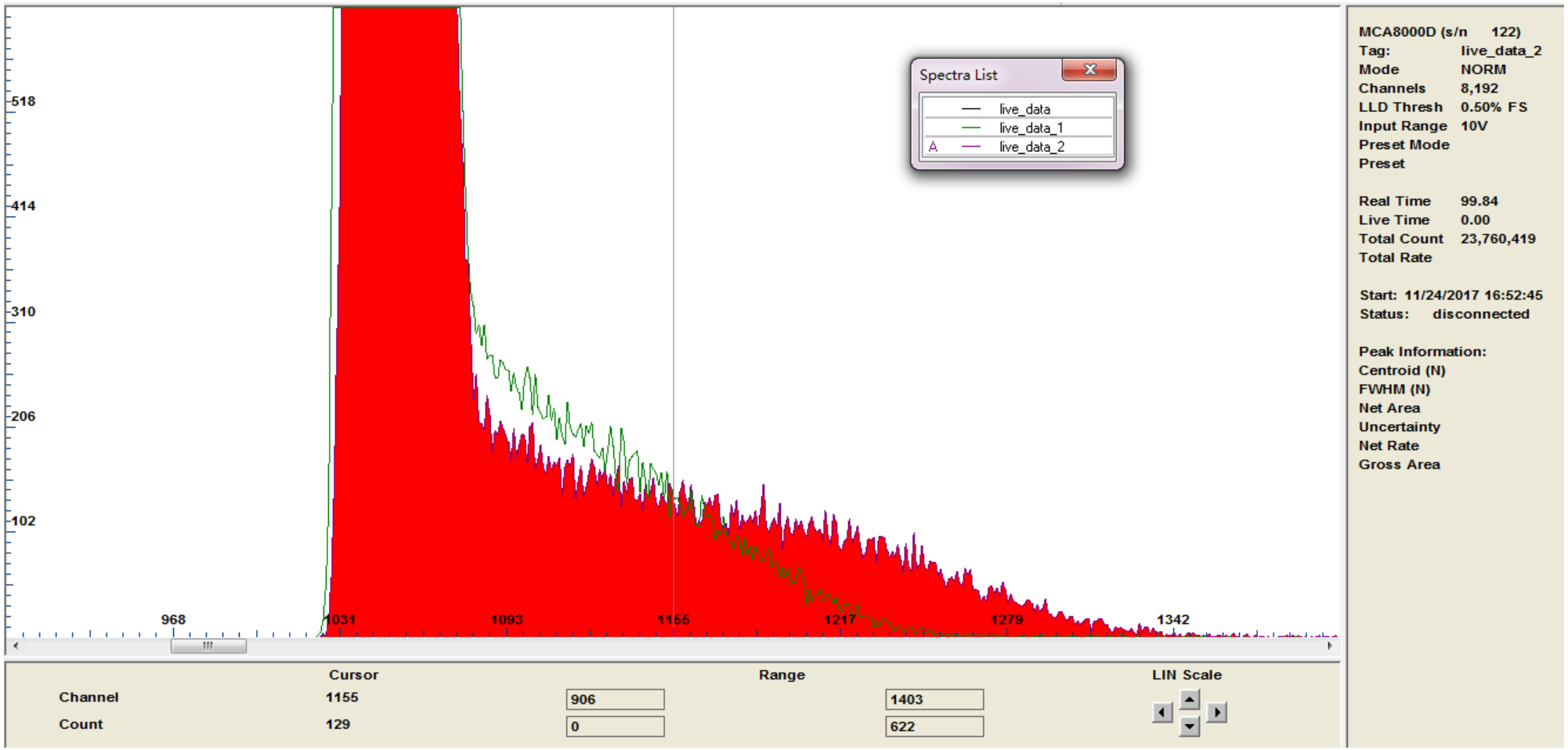


MDO3034 - 16:52:21 2017-11-24

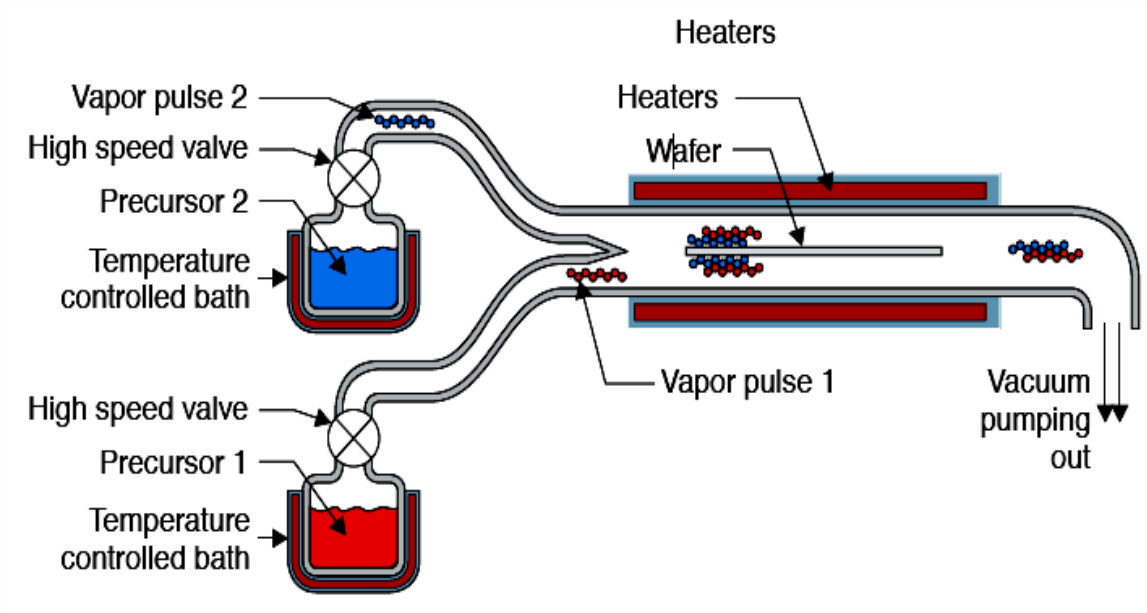
When two pieces of MCP are added to 1950V, the anode signal and the amplifier signal (assembly from MCP: 255014-3and MCP: 255014-7)

4.6 PHD （Pulse Height Distribution）of assembly

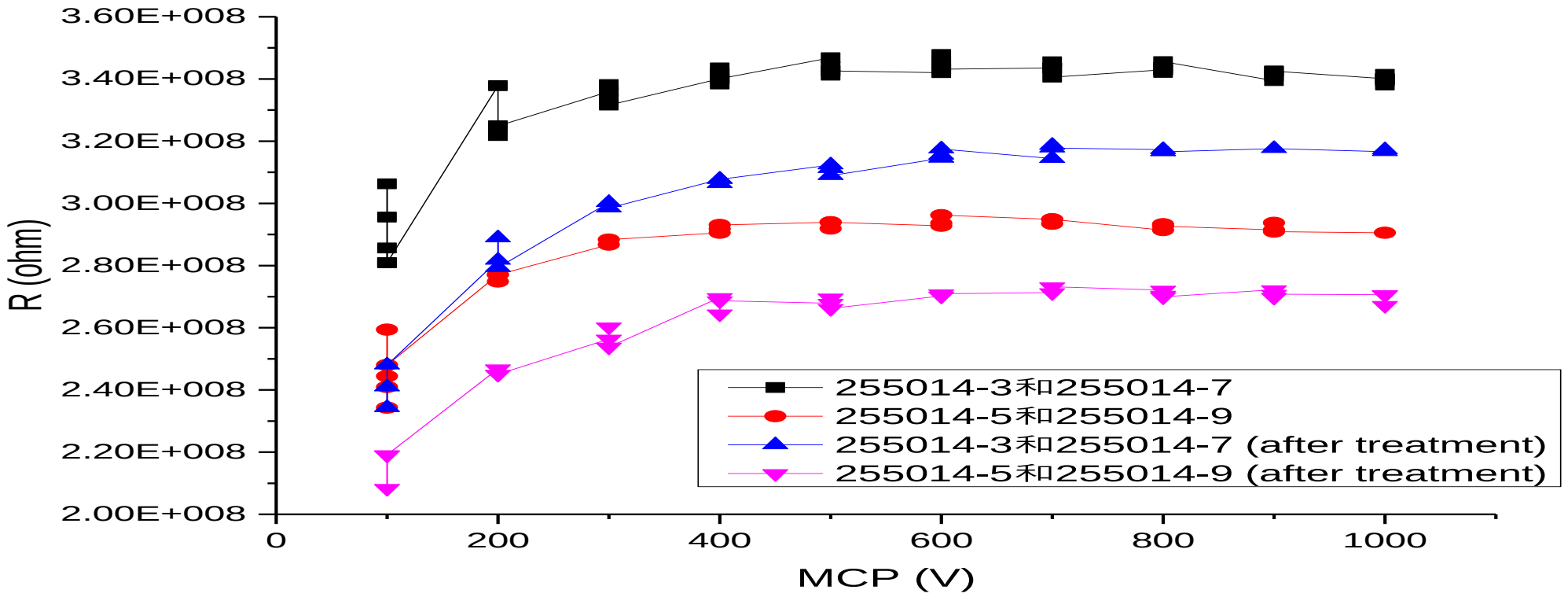


No single photoelectron peak

5.Making SEE film onto surface of channel of MCP

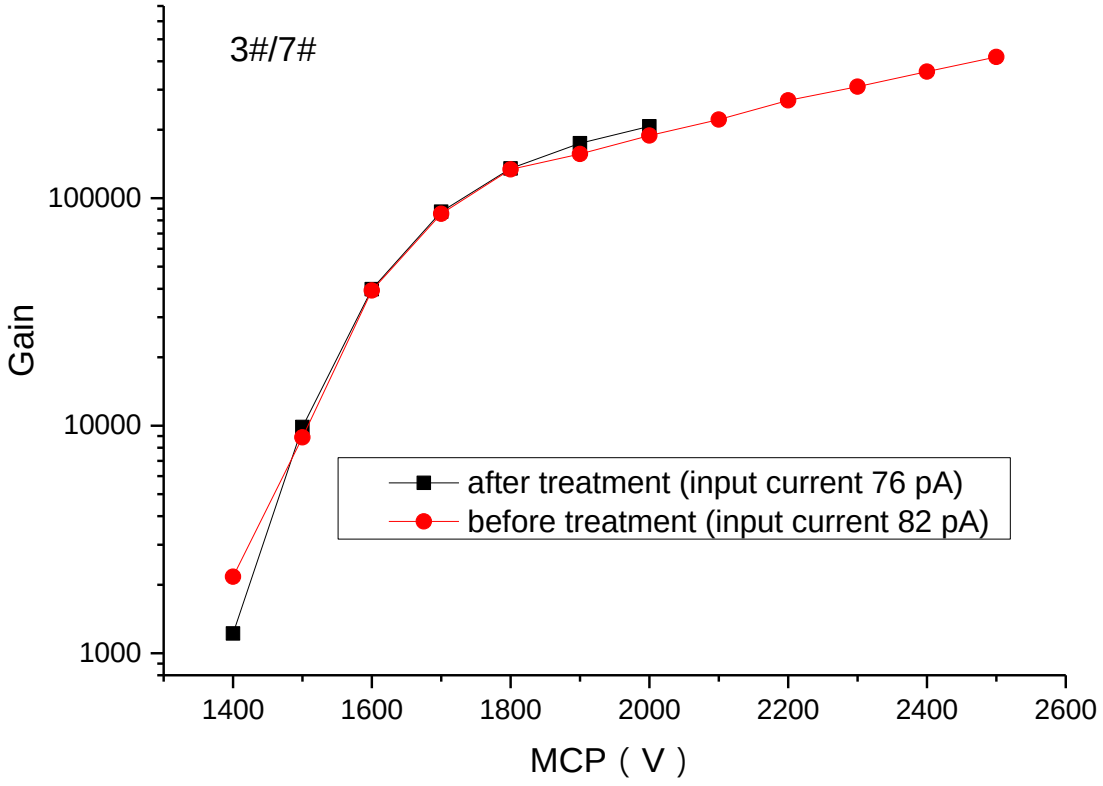


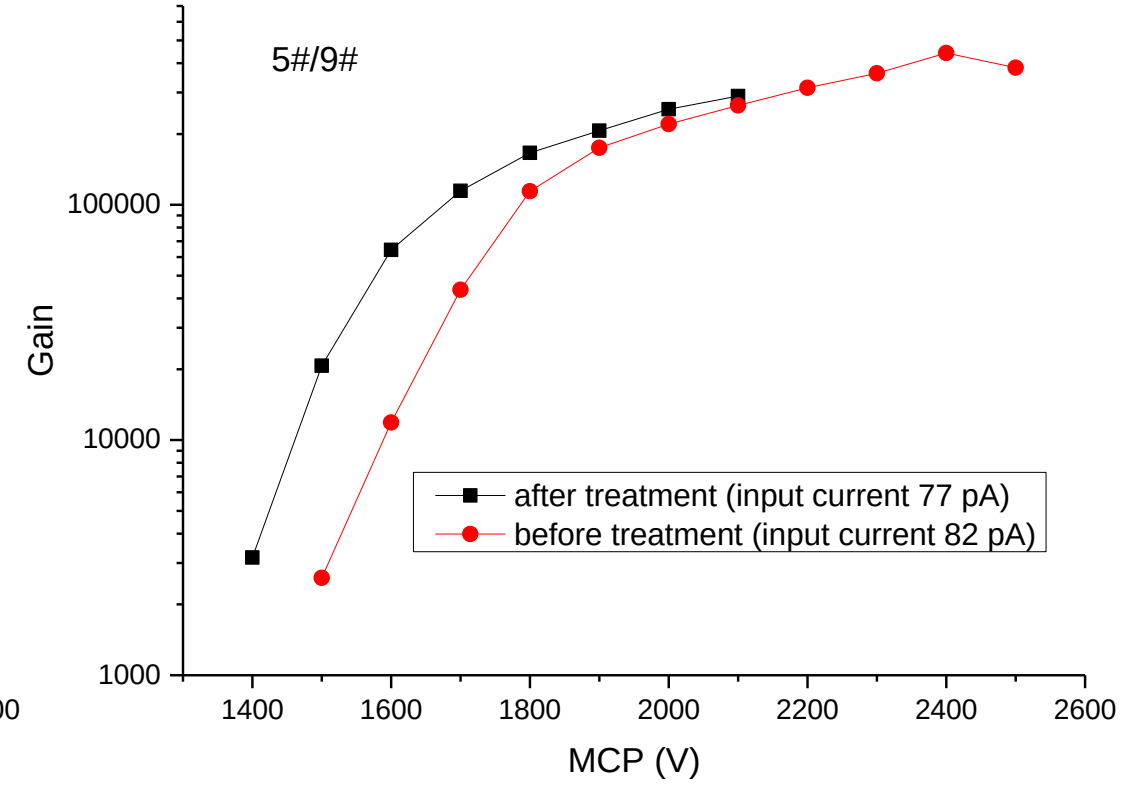
5.1 resistance of the assembly(ALD technology 4nm Al_2O_3 film)



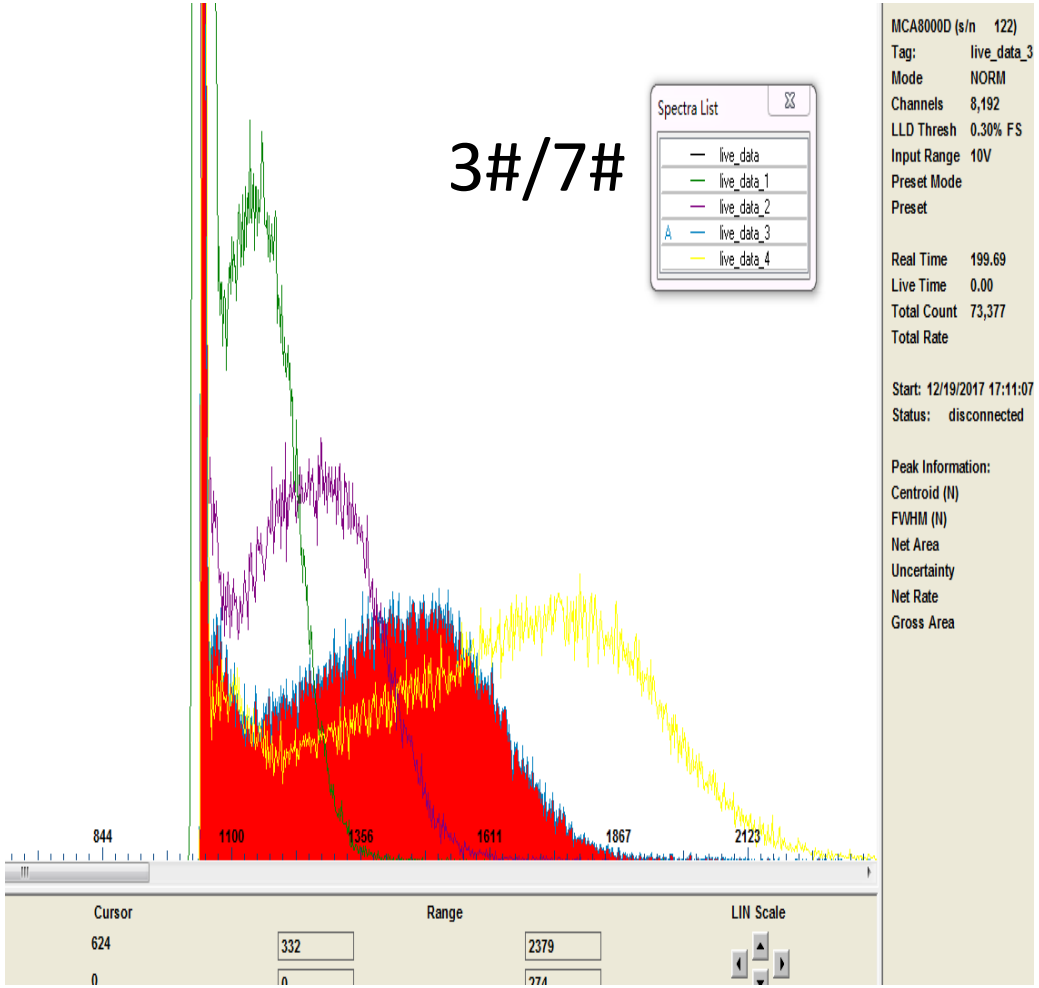
The resistance of the film with MCP is lower than that of no film from the curves of this figure.

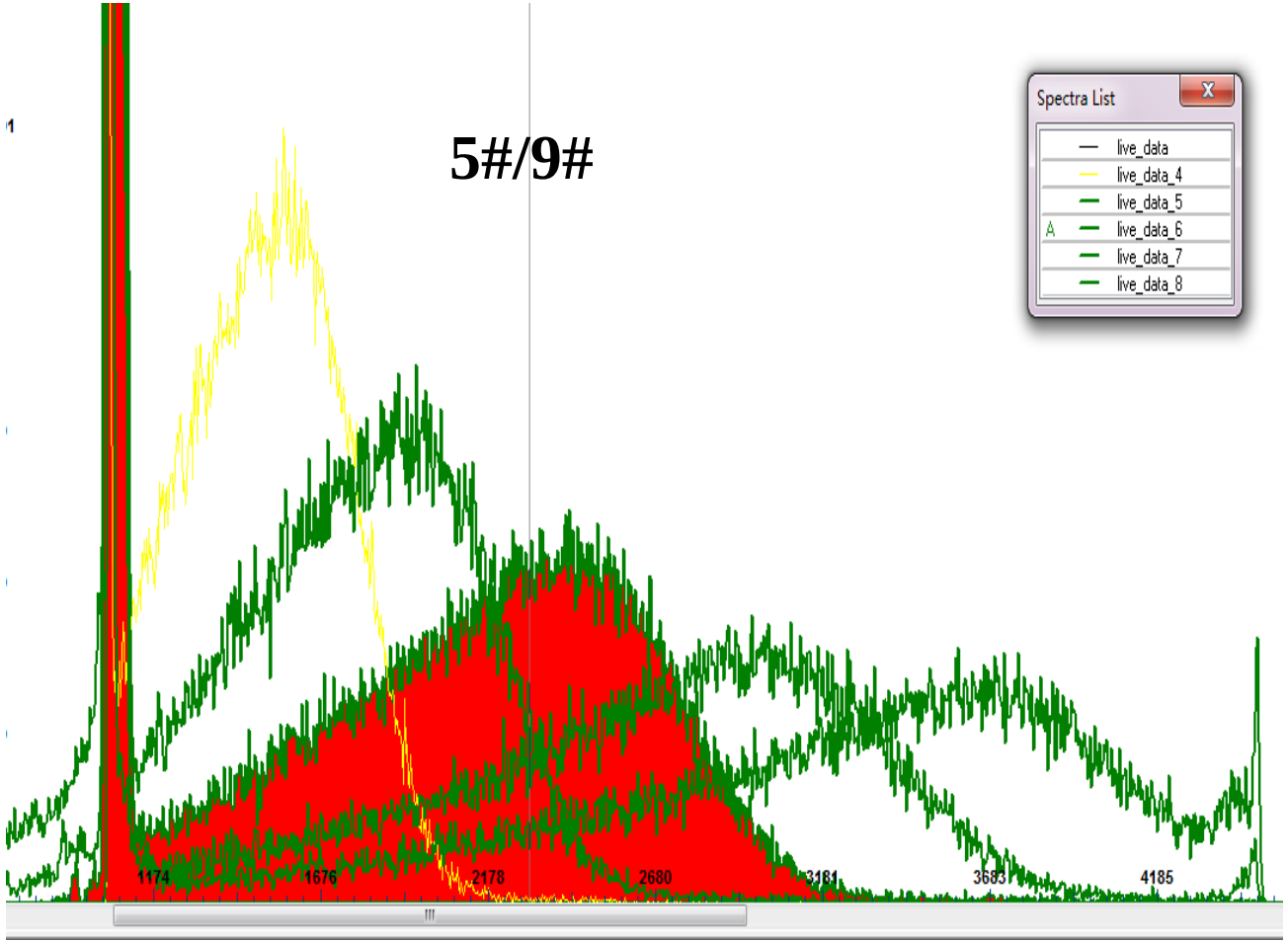
5.2 gain of the assembly(ALD technology 4nm Al_2O_3 film)





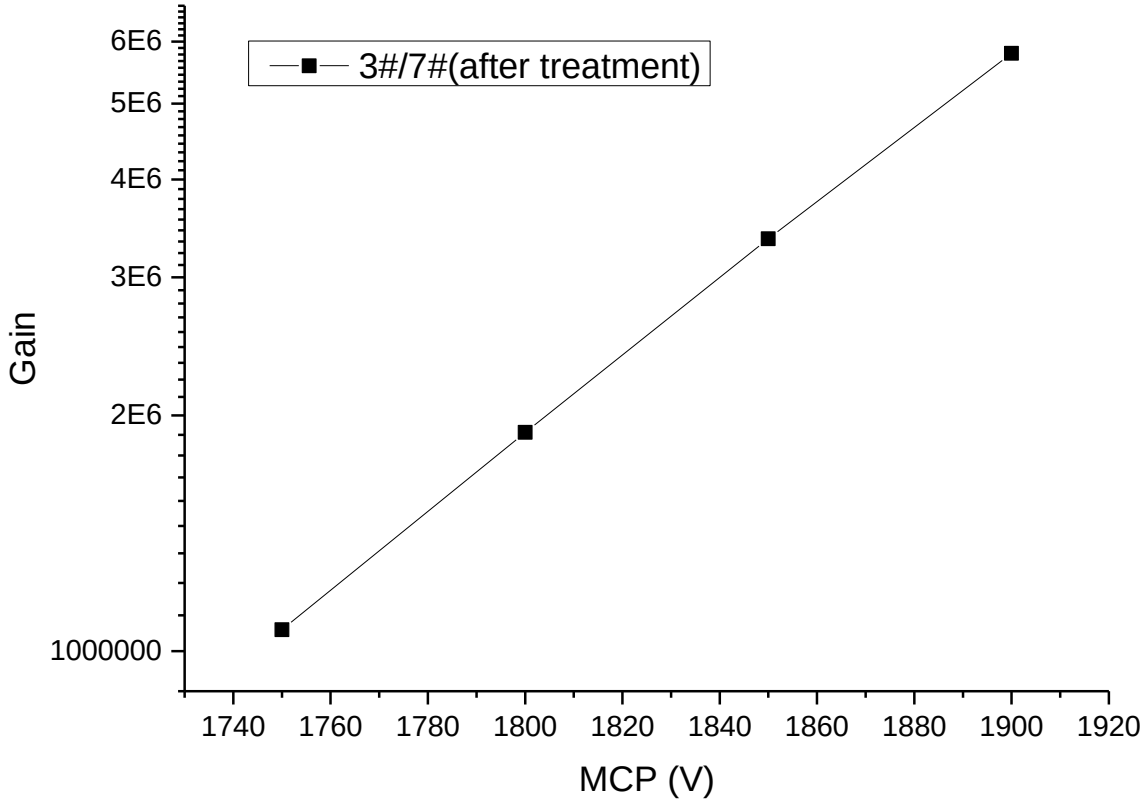
5.3 PHD of assembly (ALD technology 4nm Al_2O_3 film)

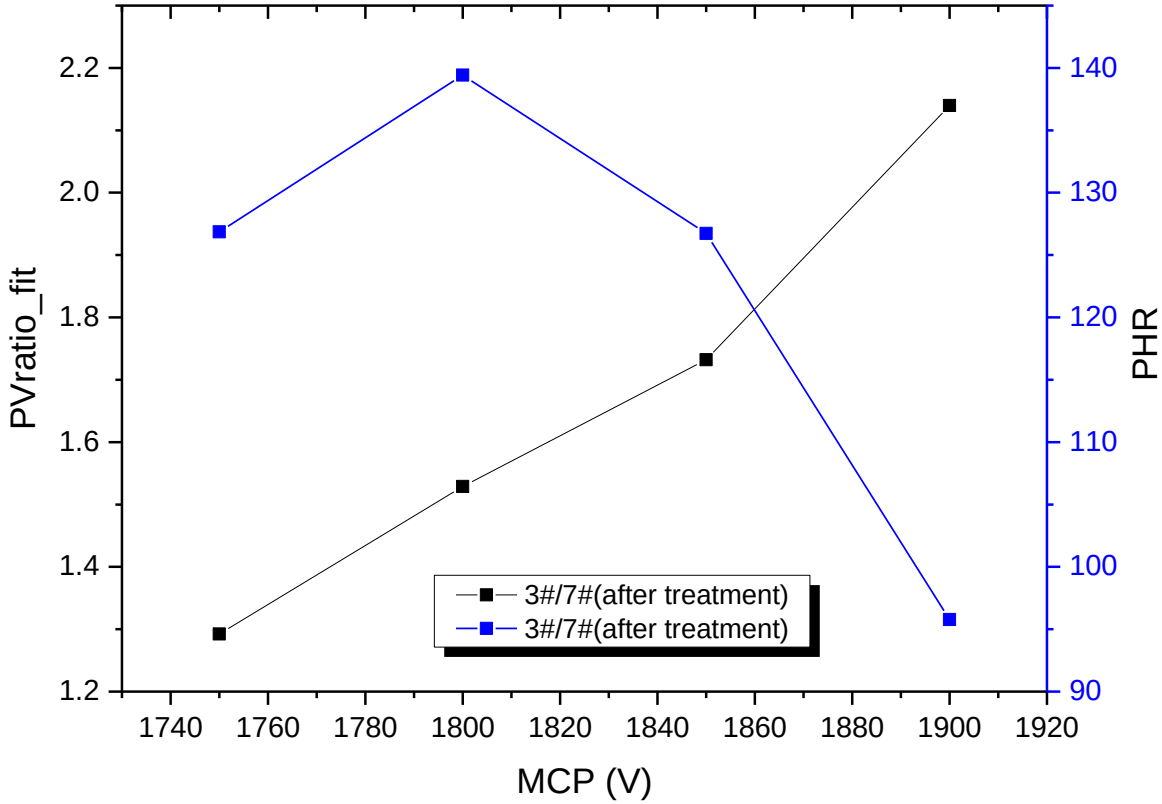


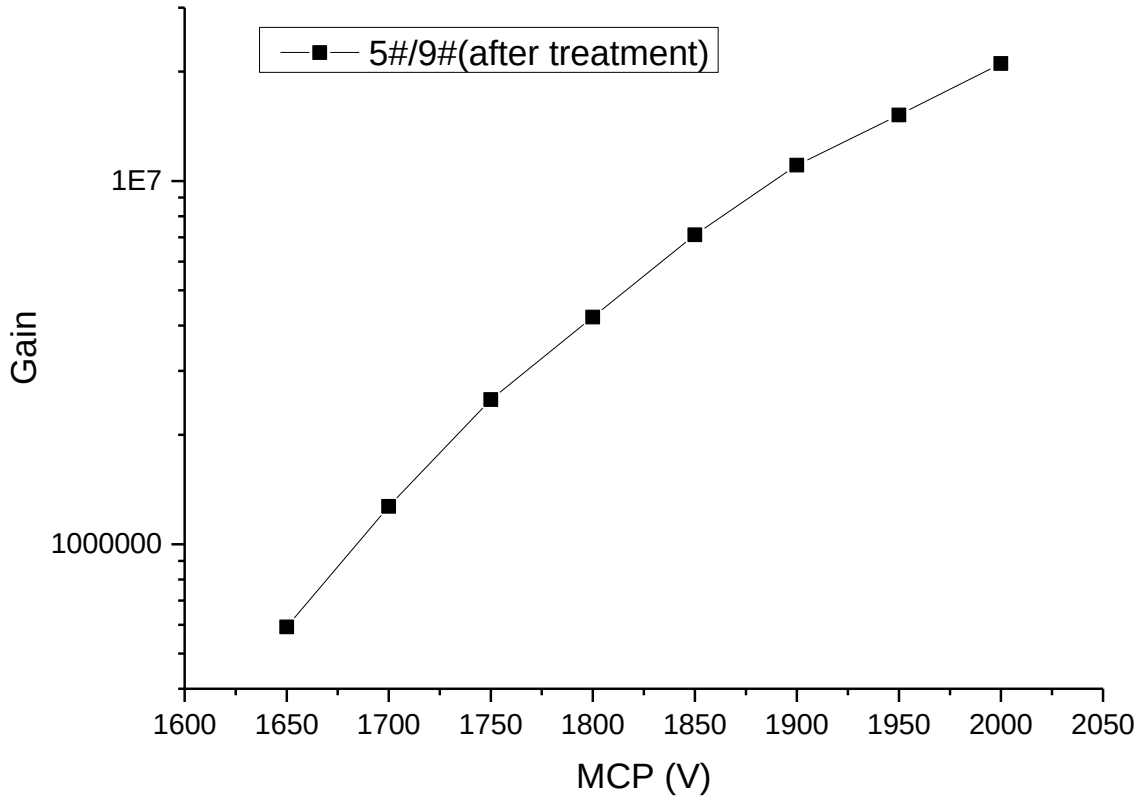


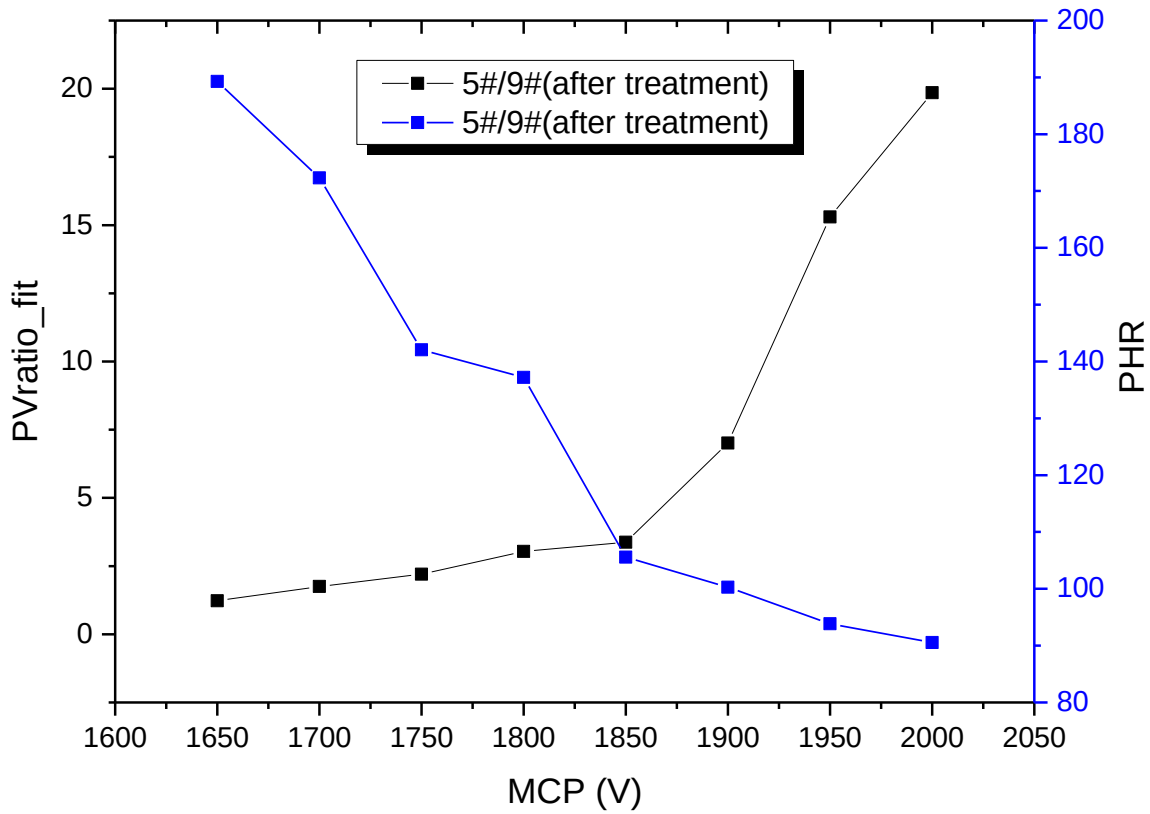
From these two pictures, we can all find the single photoelectron peak.

5.4 Gain, P/V and PHR of assembly (ALD technology 4nm Al_2O_3 film)

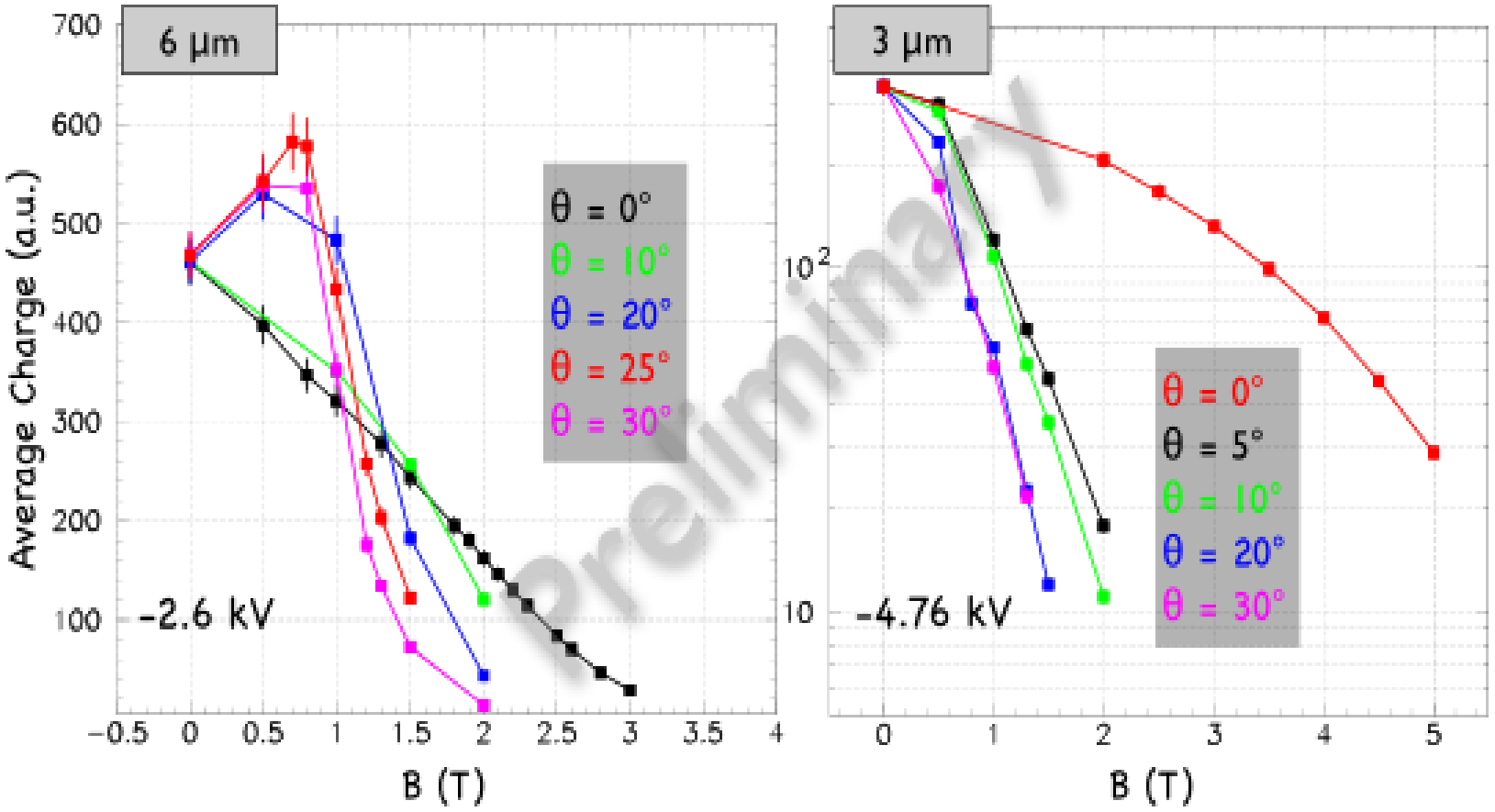





5#/9#(after treatment)
Gain
1E7
1000000
1600
1650
1700
1750
1800
1850
1900
1950
2000
2050
MCP (V)


5#/9#(after treatment)
5#/9#(after treatment)
PVratio_fit
PHR
20
15
10
5
0
200
180
160
140
120
100
80
1600
1650
1700
1750
1800
1850
1900
1950
2000
2050
MCP (V)

5.5 The ability to resist magnetic field after MCP-PMT by MCP with different pore



Y. Ilieva[a*], L. Allison[b], T. Cao[a], G. Kalicy[b], P. Nadel-Turonski[c], K. Park[b], C. Schwarz[d], J. Schwiening[d], and C. Zorn[c]

Many authors have shown that, with the increase of magnetic field and the variation of magnetic field direction and MCP-PMT axis, the performance of MCP-PMT is greatly reduced, which is not what we would like to see in practical applications.

An effective technical way to improve the ability of MCP-PMT to resist magnetic field

For the MCP-PMT which made by small pore MCP:

（1）optimize the electronic optical design in the MCP-PMT tube, increase the driving force of the electric field, and reduce the adverse effects of the magnetic field on the trajectory of the electronic motion,

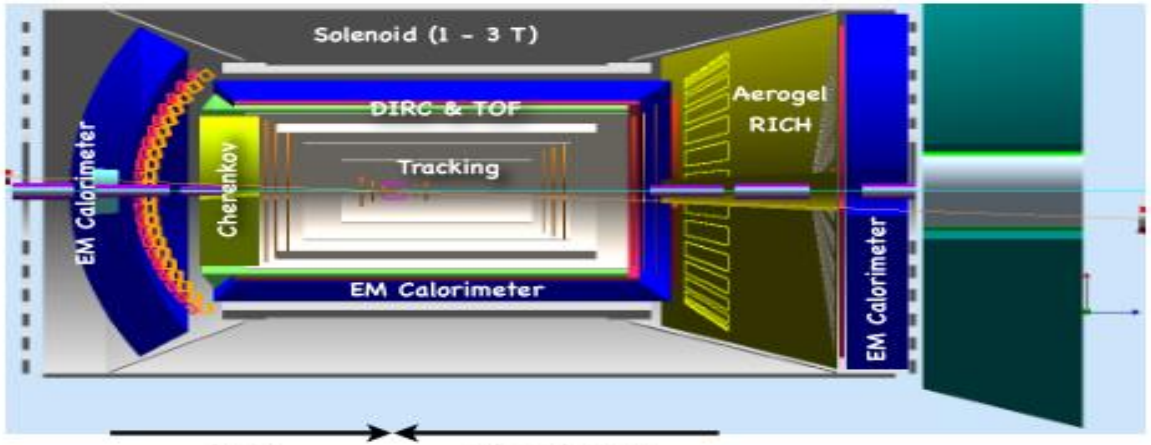
（2） to design magnetic shielding,

（3）other effective technical approaches.

6. Can we expect to use the ultra small pore MCP to make MCP-PMT in the CEPC EM calorimeter ? we are exploring…

Fundamental Problems

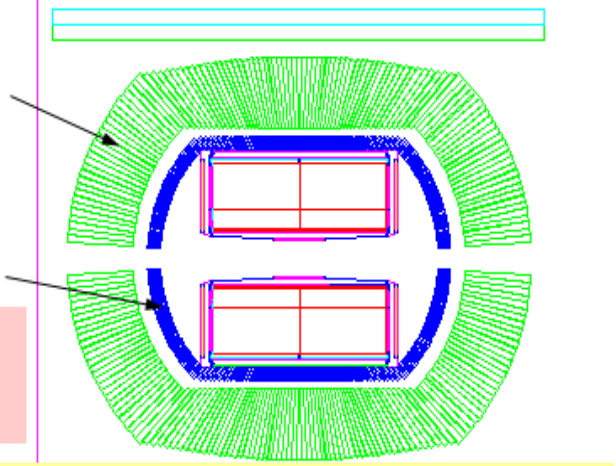
- Fiber sorting requires about 0.5 m space
- PMTs are ruled out in magnetic field > 3T
- Alternative light sensors ???



Scintillating/quartz fiber hadron calorimeter

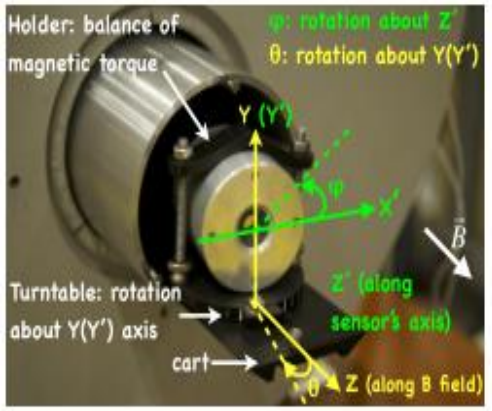
Crystal EM calorimeter

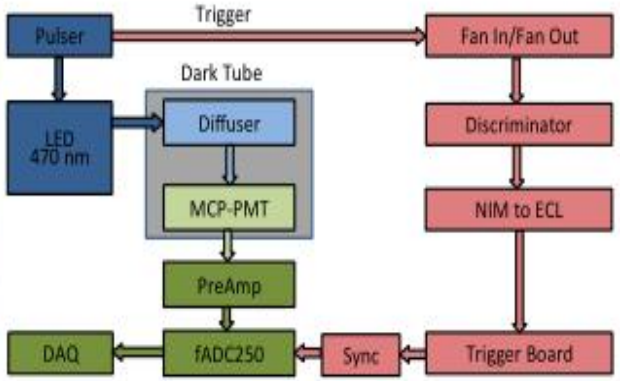
Crystal calorimeter is highly non-compensating



"4th" detector concept for ILC

From Tianchi Zhao





Summary

(1) The ultra small pore microchannel plate can improve the spatial resolution of the imaging device and the time response of the detector, but its gain will decrease. By adopting the ALD technology, we can effectively compensate for this shortcoming.

(2) We developed 5 μm pore microchannel plate and tested the performance of one and two components before and after ALD production. The latter is significantly better than the former, mainly in terms of gain, pulse height distribution and single electron peak to valley ratio.

(3) it is discussed that it can be used in MCP-PMT and can be used in strong magnetic field so as to provide the basic device for CEPC detector.

Thank you for your attention !